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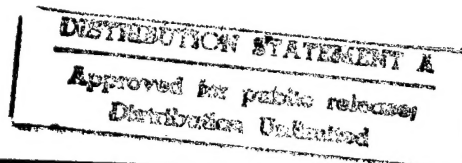
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Naval Operations in the Twenty-First Century  
Volume 1. An Overview (Navy-21)

National Research Council, Washington, DC

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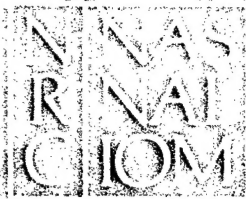
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## Implications of Advancing Technology for Naval Operations in the Twenty-First Century

Volume I: Overview

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**IMPLICATIONS OF ADVANCING TECHNOLOGY FOR  
NAVAL OPERATIONS IN THE TWENTY-FIRST CENTURY  
VOLUME I  
OVERVIEW**

Naval Studies Board  
Commission on Physical Sciences,  
Mathematics, and Resources  
National Research Council

NATIONAL ACADEMY OF SCIENCES  
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Washington, D.C. 20418

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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## PREFACE

With representation from his Executive Panel, Admiral James D. Watkins, (then) Chief of Naval Operations, met with Dr. Frank Press, President of the National Academy of Sciences, Dr. Robert J. Hermann, Chairman of the Naval Studies Board (NSB), and Vice Admiral William J. Moran, USN (Ret.), NSB member, on June 2, 1986, to discuss his interest in having the NSB undertake a major study to address the implications of advancing technology for naval operations in the twenty-first century. The general agreements reached in that meeting were reflected in Admiral Watkins' letter to Dr. Press of June 20, 1986, in which he formally requested that the NSB undertake the study. He indicated that the incoming Chief of Naval Operations, Admiral Carlisle A. H. Trost, would be briefed on the matter during transition, and suggested that a delegation from the NSB call on Admiral Trost after he took office, which was done at Admiral Trost's request. Dr. Hermann, Vice Admiral Moran, and the NSB's Staff Director, Mr. Lee M. Hunt, met with Admiral Trost on August 22, 1986. Admiral Trost indicated his full approval and endorsement of the requested study, and formalized that endorsement in his letter to Dr. Press dated August 20, 1986. The terms of reference ultimately agreed upon are reproduced below.

### Terms of Reference

Determine the implications of advancing technology for naval warfare in the twenty-first century, with particular emphasis on:

- New technologies affecting naval forces in the 1987-2030 time frame.

- Implications for traditional force structures.
- Impact on U.S. maritime strategy.
- Potential adversarial responses.

At its next regularly scheduled meeting on June 19-20, 1986, held at the Naval War College in Newport, Rhode Island, the NSB members unanimously agreed to undertake the requested study. It was enthusiastically approved by the Commission on Physical Sciences, Mathematics, and Resources on October 3, 1986, and by the Governing Board of the National Research Council on October 17, 1986.

The NSB's next two meetings, held on September 15 and November 18-19, 1986, were devoted to designing the study, laying out a rough schedule of events, and selecting the study leadership. It was decided that rather than have the NSB serve as an oversight body for the effort, the entire membership would be asked to assume leadership positions within the study structure. Thus, the NSB's chairman became the study director, Vice Admiral Moran became the study executive director, and the remaining members served as chairmen or key members of the several task groups as reflected on the organizational chart.

To provide for an independent review of the study results as they evolved, an Advisory Council was established under the chairmanship of Dr. Charles Herzfeld. The Advisory Council met on four milestone occasions during the course of the study to review and comment on the interim findings. The fourth meeting--held on March 24-25, 1988--was spent in reviewing the final version of Volume I, the overview report.

The Coordination and Integration Group was established under the chairmanship of Mr. Seymour Deitchman. The group served as the single body responsible for coordinating and phasing the study activities, collecting the output from the several task groups, and integrating findings into an overview report on a near-continuous basis. The process also served to identify conflicts, areas of excessive overlap, and gaps in coverage among the task groups. The evolving overview report, along with the individual task group reports, was reviewed by the Advisory Council and the working group chairmen at appropriate intervals.

The Threat-Intelligence Group, under the chairmanship of Dr. Eberhardt Rechtin, was established to serve as a "Red Team" to evaluate and criticize the study findings as they evolved, and to determine the most likely response to those findings by a sophisticated adversary. The findings of this group were also subject to review by the Advisory Council.

The identification of those present, emerging, and projected technologies likely to have the greatest impact on the future Navy and Marine Corps was carried out by all of the task groups in the course of their deliberations. However, a Technical Support Group, under the chairmanship of Dr. Alan Berman, was established to formalize this process and to serve as a technical advisor to all of the other groups.

The Naval Forces Concepts Group was established under the chairmanship of Mr. David Heebner. The purpose of the group--with the chairmen of the other task groups serving as members--was to monitor the evolving study findings and suggest new or additional ways in which the fleet of the future could be used to greater advantage. As might have been anticipated, once the study gathered momentum, concepts began to emerge from all elements of the study.

To address the major elements of the Navy and Marine Corps it was decided not to break the study down into mission or warfare areas, but to subsume these considerations under logical technological groupings in order to emphasize the concentration on feasible technical advances. This decision resulted in the following task groups: (1) Space Technology Group; (2) Radio-Electronic Battle Management Technology Group; (3) Underwater Vehicle Technology Group; (4) Surface Vehicle Technology Group; (5) Atmospheric Vehicle Technology Group; (6) Amphibious Warfare-Marine Corps Technology Group; and (7) Education, Training, and Manpower Technology Group. Although the concentration of each group was on platforms and platform technology falling into its area of responsibility, each group was also responsible for all systems required to support those platforms, including weapons. However, it was realized that within a manageable size task group, it was unlikely that all areas of expertise could be adequately represented. Therefore, a Special Projects organizational box was formed to assist the task groups in such areas. Prominent among the

special projects undertaken during the course of the study were (1) warheads and weapons, (2) automation and robotics, and (3) logistics. Other ad hoc groups were formed during the course of the study for detailed consideration of topics such as mine and mine countermeasures technology, torpedo technology, missile technology, gun technology, directed energy weapons technology, and methods of nontraditional attack. It should also be noted that the NSB's Space Panel, with its membership slightly augmented, became the Space Technology Group. The Combat Networks for Distributed Naval Forces Panel, having just completed its report on a global information net, served to input and interpret its findings for the study as a whole, but with particular relevance to the Radio-electronic Battle Management Group.

Ever since the establishment of the NSB, the Chief of Naval Operations' designated representative has been the Director, Research, Development, and Acquisition (OP-098). In that capacity, Vice Admiral Albert J. Baciocco, and his successor, Vice Admiral Paul F. McCarthy, assisted in the formation and launching of the study, arranged the necessary financial support, and attended all milestone meetings. However, with OP-098 concurrence and assistance, the NSB sought to establish a bridge to the Navy and Marine Corps that was unique to the study and capable of working with the study leadership on a frequent contact basis.

Therefore, both the Chief of Naval Operations and the Commandant of the Marine Corps were asked to identify their own Special Representative to the study to serve as a communication link, to assist with access problems, and to interact with the study group on policy and operational matters. Rear Admiral David R. Oliver and Colonel Marshall B. Darling were designated to these positions. In addition, and for similar purposes, a Navy or Marine Corps officer was detailed to serve as liaison with each of the task groups. The liaison officers also served to identify sources of information and briefings of interest to their respective groups. Those serving as liaison officers are noted on the membership list under the group with which they served.

The remainder of 1986 was devoted to identifying members for each of the task groups. Nominees with unique experience and demonstrated scientific, engineering, or operational excellence were drawn from academia, industry,

and government agencies. Ultimately, 188 such experts were selected and approved by the NSB and the NAS membership approval process. Although a couple of the task groups held their organizational meetings in late 1986, the study entitled *The Implications of Advancing Technology for Naval Operations in the Twenty-first Century* (Navy-21, for short) officially began on January 1, 1987. Admiral Watkins had asked that the study be completed in 2 years, and it was officially terminated on June 1, 1988.

During the 18 months of concentrated study effort, the guiding philosophy established by the leadership became known as "controlled chaos." That is, the individual task groups were given wide latitude in interpreting their original tasks, and in setting their own pace. The purpose of this approach was to stimulate innovation and to allow each group to follow any lead it considered profitable. Near-constant communication between groups was provided through several different devices. Each task group chairman, or his designated representative, was encouraged to attend the formal meetings of all other groups. Working papers and interim reports produced by each group were distributed to the chairmen of all other groups as soon as they were received by the Coordination and Integration Group. In like manner, the interim overview reports, produced at frequent intervals by the Coordination and Integration Group, were made available to each task group for comment and suggested changes. To formalize this process, the study leadership and the task group chairmen met with the Coordination and Integration Group on four different occasions to review interim findings, identify remaining issues, and continue plans for the next study phase. In addition, on September 25-28, 1987, and February 16-17, 1988, a large meeting--consisting of the study leadership, all group chairmen plus key members of their task groups, and all Navy and Marine Corps representatives--met at the Naval Ocean Systems Center in San Diego, California, to review both the findings of each group and the interim overview report. The results of these meetings were subsequently discussed with those task group members not attending.

In addition to allowing for maximum communication among the 21 individual groups, the group meetings noted above, plus the four meetings with the Advisory Council,



allowed the study leadership to gain approval of the study findings, subject to changes suggested during the meetings, at appropriate milestone intervals. The February meeting at San Diego and the March meeting with the Advisory Council were used to gain approval of the final draft of the overview report. In turn, the Volume I: Overview, fully approved by the study group and the Advisory Council, was given a final review and approval by four prominent scientists designated by the Report Review Committee of the National Academy of Sciences. The individual task group reports from which the Overview (Vol. I) Report was drawn are issued separately as Volume II, Threat-Intelligence; Volume III, Assessment of Some System and Technology Drivers; Volume IV, Space Technology; Volume V, Radio-Electronic Battle Management; Volume VI, Underwater Vehicle Technology; Volume VII, Surface Vehicle Technology; Volume VIII, Atmospheric Vehicle Technology; Volume IX, Amphibious Warfare-Marine Corps Technology; Volume X, Weapons and Warheads, Appendix A - Surface Weapons, Appendix B - Mines and Mine Countermeasures; Volume XI, Manpower, Logistics, and Robotics.

The National Academy of Sciences, its National Research Council, and its Naval Studies Board wish to acknowledge their indebtedness to the Navy and the Marine Corps for the effective support provided during the course of this study. No area, no matter how sensitive, was placed out of bounds, and the study group received only encouragement in pursuing technical and operational arguments to their logical conclusions. In like manner, we wish to express our appreciation to those Navy and Marine Corps liaison officers who provided invaluable service to the study leadership and the individual task groups, and to the hundreds of briefers from government, industry, and universities who took the time to share information relevant to the study deliberations.

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## SYNOPSIS

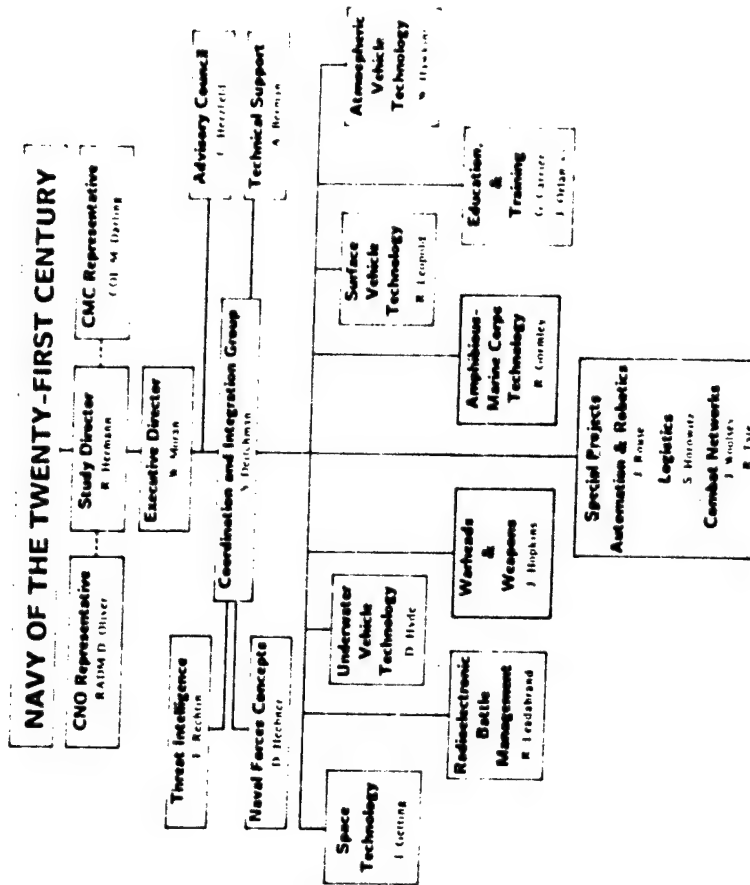
### A. OBJECTIVES, SCOPE, AND APPROACH

This report of the Naval Studies Board (NSB) explores, at the request of the Chief of Naval Operations (CNO), trends in technology that may affect the Navy in the twenty-first century. In initiating the study, the CNO asked how the future technological trends might change Navy force structure, what the impact of those changes on U.S. maritime strategy might be, and how the Soviet Union might respond.

To answer these questions, the Naval Studies Board as a whole constituted itself as the study panel, and established a number of subgroups, including many individuals representing all the relevant areas of expertise, to deal with specific areas of technology and specific issues in the application and integration of the technology. The participants--along with the resulting reports--are listed in the introductory pages of this volume. The study organization is shown in the diagram on the next page.

The study was organized around the broad technological areas from which maritime power flows. Special attention was given to those areas of technology (see Volume III) projects) that the panel believes will become particularly important to naval forces in the future. Altogether, some 188 people participated in this study over the period from January 1987 to May 1988. Close coordination with the Navy and Marine Corps was maintained through the efforts of some 22 liaison officers. Many prior NSB studies and relevant recent or ongoing studies by other groups and Services were used as background, in addition to the original work performed by the panel. The Advisory Council reviewed the study results periodically and provided invaluable advice on directions, scope, and interpretation.

The following rationale and premises underlie the study:



1. The technology assessments are based on a view of how technology may develop over the next 10 to 20 years, but we expect that the anticipated developments will influence the Navy over a 30- to 50-year period. That is about the length of time it will take for naval (and other) systems and forces to fully absorb large numbers of new technological developments begun today, and for the effects of the resulting changes to be felt at all levels of naval and other Service organization and operation.
2. Prediction of breakthroughs, or of precisely how the Navy will evolve over the time period of interest, is obviously beyond the capability of any group. A major new technology of the magnitude of nuclear propulsion or modern solid-state electronics could change the "future" that the panel has described, perhaps quite drastically. The panel's assessment examines how technologies that are appearing now may evolve and, given that evolution, the impact they may have on both the maritime warfare environment and the Navy itself. This includes technologies that have existed but that may be applied in new ways because of interaction and synergy with newly emerging technologies. Even within this domain, the changes we foresee are quite extensive.
3. The Soviet Union will probably remain the primary military antagonist of the United States and its allies. It is difficult to foresee a different, major technological and geopolitical force emerging to displace the USSR in this role over the time period covered by the study, although other forces will be operating and the design and utilization of the Navy will have to account for them.
4. Prominent among these "other forces" will be Third World countries equipped with increasingly sophisticated weapons. There is no evidence that the experience of the past 40 years will not be repeated over the next 40. Therefore, the Navy and Marine Corps must be prepared to deal with lesser conflicts, and expect to be repeatedly called upon to do so.

5. Even though the emphasis is on the Navy, the Navy must be concerned with "maritime warfare" as a whole, rather than with "naval warfare" only. This encompasses consideration of joint and combined forces, approached from the point of view of the Unified Commander responsible for operations in a geographical area of the globe. This includes all the forces the CINC (Commander in Chief) must operate and all the assets that may be available to him under his own command and from higher authorities to help him fulfill his mission.
6. Strategic defense will be a continuing area of concern to the nation throughout the period of interest, and technologies that may emerge from the Strategic Defense Initiative (SDI) or any evolutionary derivatives from that program will be of continuing interest and benefit to the Navy. The potential for joint Navy-SDI activities will become apparent as strategic defense systems are defined and deployment is contemplated.
7. The study made no assumptions about the future arms control environment or new arms control agreements that might be reached. Many of the qualities of the future Navy that we anticipate and the potential directions of evolution that we explore can be affected by new agreements in this area, but they would not be wholly invalidated by such agreements. The most critical such areas are indicated where appropriate.
8. Similarly, although it is apparent that energy availability will be a continuing source of domestic and international economic and political tension, the study did not speculate on the possible consequences of such tension for the U.S. military environment, including the Navy. We believe that regardless of the overall energy situation the military forces will have the fuel they need. We did not examine how international conflict over energy as distinct from conflict for other reasons, or possibly drastic changes in the civilian energy economy, might affect the armed forces.
9. The panel did not wish its deliberations to be constrained ab initio by resource issues, but it also did not want to indicate directions of evolution that would be

unrealistic in a resource-constrained world. The potential and desirable changes induced by technological advance, if all of them were implemented, can be so extensive as to demand resources well beyond those likely to be available during the period of concern. We did therefore address resource issues, but in broad terms without attempting a level of detail that would be more appropriate for a programmatically-oriented review.

The technologies and their implications were reviewed in terms of directions of development that will be forced by threat and environment (i.e., the Navy must pursue these areas and lead in them or be left behind to the detriment of national security), and technological opportunities to achieve new capabilities or perform continuing tasks in new and better ways. These reasons for advancing technology are, of course, interrelated.

From this base, the panel attempted to make its conclusions and recommendations as sturdy as possible to the uncertainties of the future. It must be noted in this context that there are so many areas of technology involved in an enterprise as large as the U.S. Navy and the Marine Corps that failure to mention an area of technology or a type of system does *not* imply that the panel thinks it is unimportant, merits reduced emphasis, or will be profitless if pursued. The conclusions of the study refer to what is treated explicitly in the study, and carry no implication for what is not treated.



## B. OVERVIEW

### 1. The Future Maritime Warfare Environment

Since any study such as this faces an inscrutable future, the panel thought it best simply to articulate some of the possible trends in environment and opposing forces that might be anticipated today, and then to ask whether the associated projections of technology and its impact on maritime warfare problems and forces would remain sturdy to the uncertainties of that look ahead. The panel believes they do.

The Soviet Union is expected to achieve many of the same technical capabilities as the United States over the time period, and to apply some of them in innovative and surprising ways. Soviet expansion of a base structure into Third World areas can be expected to continue. China could emerge as a major, modern industrial and military power over the next 50 years, and Japan may pay more attention to military matters than is currently the case. The U.S. and the world economies will become increasingly intertwined, continuing into the indefinite future today's trend to internationalizing the U.S. economy. The world economic environment and competition among the United States and its allies for markets will encourage the spread of advanced civilian and military technologies to Third World countries as well as to advanced industrial nations that are neutral or associated with either the Western or the Soviet alliances.

U.S. maritime forces will therefore increasingly have to face potential conflict in many directions and areas, including third countries having advanced military equipment. The growing diversity and intensity of local political interests are likely to make our overseas base structure less secure, thereby enhancing the importance of a forward position based on flexible, mobile maritime power having less dependence on a fixed base structure. The defense of the sea lines of communication with our allies and sources of economic strength will become at once more important and more difficult. The potential for extended warfare in which a battle for control of these lines of communication comes to the forefront may well be increased even more by the prospective reduction of U.S. and Soviet nuclear

forces and enhancement of conventional warfare capabilities on the part of diverse potential antagonists.

The driving factors in this environment that will press the Navy to change its current systems and operations include increased vulnerability, in times and areas of crisis, of all surface and air assets to early detection and attack with weapons of increasing effectiveness, and pressures of increased resources required to meet the challenges of the increased vulnerability. At the same time, advanced technology will offer opportunities to mitigate the vulnerability problems within the scope of resources likely to be available. A key threat to the U.S. Navy will include Soviet Navy undersea operations in a "fleet" mode, based on a highly integrated Command, Control, Communication and Intelligence (C<sup>3</sup>I) system. Stealth and counterstealth technology will be among the most important opportunities and "drivers."

## 2. A "Vision" of the Navy 30 to 50 Years Hence

It is perhaps not commonly recognized that over the next 30 to 50 years the nation will in the normal course of events be replacing the current Navy with an entirely new one. The issue is therefore not whether that should be done, but rather, what the new forces will look like. The panel's review has led to the following "vision" of the Navy 30 to 50 years hence:

- The contest for information will dominate maritime warfare.
- Surveillance that is global in scope will be a routine feature of military operations.
- Significant portions of U.S. and opposing forces will incorporate stealth technology.
- The "battle space" will continue to expand--forces will cover more area while becoming more tightly integrated through the information system.
- Space will have become an additional zone of conflict related to maritime warfare.
- There will be more emphasis on undersea warfare.

- Surface and air forces will be greatly transformed, to accommodate to the environment of increased vulnerability from all quarters.
- Precision-guided weaponry will proliferate: tactical long-range firepower in the form of cruise and ballistic missiles will be dispersed to many surface ships other than carriers as well as to submarines; carrier aviation will use more guided standoff weapons; and unmanned systems will assume many of today's combat and support functions.
- The design and modes of operation of the amphibious forces will change to permit greater maneuvering speed and flexibility of lighter but more powerful forces from longer distances to landing zones.
- Manpower numbers will decrease while training, system design, and logistic practices will be changed to accommodate more sophisticated forces spending longer periods away from secure bases with less underway support.

The panel has reviewed the purposes and missions of the Navy in light of the evolution we foresee and has concluded that they will change very little, although the way they will be carried out is likely to change substantially. Vulnerability and countersurveillance will induce greater dispersion of forces for cover, surprise, and deception; long-range weapons will extend the battle space of maritime warfare forces, making greater dispersion and geographic coverage possible. However, stealth technology will reduce the self-protection battle space of individual force elements. Only the surveillance, countersurveillance, and combat information systems will permit any naval force to function in its entirety as an integrated combat system able to "hit any target from any location" and to defend itself effectively from enemy counterattack.

Although steps will be available to reduce the need, some level of support and replenishment of forces at sea will remain necessary, especially in times of intense and protracted operations. The supporting ships and the shipping on the sea lines of communication that the fleet will have to protect as part of its sea control mission will be subject to the same considerations of vulnerability and protection as the surface combat forces.

Protection of the fleet logistic system and SLOC shipping as the submarine and airborne missile threats increase will require countermeasures of increasing intensity and expense. They will run the gamut from changed sailing practices through arming many of the commercial and logistic ships to embedding them within the full fleet combat system or, ultimately, using the Navy to carry militarily vital cargo. The combination of threat and availability of submarines having very large displacements may at some point make it economical and desirable to transport militarily important cargo in wartime on submarines designed for the purpose.

Both the United States and the USSR are moving toward powerful undersea strike forces that will be very hard to detect and defend against. The side that wins the information war for detection, tracking, targeting, and denial of these capabilities to the other side will have the edge.

Limits on the flight ranges and total numbers of tactical conventional cruise missiles could emerge from Strategic Arms Reduction Agreements on sea launched cruise missiles. They could be applied later to fleet-based tactical ballistic missiles in an extension of the INF treaty. Under such limits the critical importance of the information-, communication-, and signature-related technologies would remain. Shorter-range cruise, ballistic, and defensive missiles, whether air or surface launched, would still be useful and needed. There would, however, have to be more reliance on air-delivered weapons for attack of difficult targets from long range. This could affect the justification for extensive dispersal of tactical firepower to ships and submarines via long-range missiles that the panel foresees (and that will be described throughout this report). The extent and desirability of such dispersal would therefore have to be reviewed in light of the characteristics and utility of the missiles actually agreed upon and vice versa.

### 3. Surveillance, Combat Information, C<sup>3</sup>

The panel used the term Radio-Electronic Battle Management (REBM) to encompass the functions of intelligence, surveillance, and reconnaissance; command, control, and communications; all technical operations on information; electronic and electrooptic

warfare coupled with signature management or "observability warfare"; and targeting. We believe that radio-electronic battle management must be treated as an organic whole to ensure success in the "information war."

The capacity to exercise and use the results of surveillance that is global in scope, using sensors that range from those in the tactical forces through major undersea, over-the-horizon radar and space systems, and to ensure secure and unexploitable communications connectivity among information assets, surface forces, air forces, and submarines is only partially available as yet. Even when it is, the Navy will not control all the required resources. Urgent attention will have to be given to creating the full capability for obtaining, assessing, and communicating information with certainty to our forces and denying it to opposing forces, by all available technical and operational means, including integration with other Services and non-DoD (Department of Defense) agencies to ensure availability of the resources.

Total signature management to the greatest technically feasible extent for all naval forces, including integration of stealth, counterstealth, and electronic/electrooptic warfare systems, will be needed in the future for the Navy to function effectively. This capability is intimately related to the global surveillance and communications connectivity requirements.

In connection with these points:

- a. The panel believes that continuing great strides in computer hardware and software will be of extreme importance to the Navy for its combat information network and battle management. This is an area of great U.S. advantage currently, and the Navy should make every effort to play a major role in advancing and using these capabilities.
- b. The panel is impressed with the extent and importance of Soviet ocean surveillance and signature management activities; awareness of these activities enhances the panel's feeling of urgency for application to U.S. systems.
- c. The panel believes the United States must continue to maintain high-confidence, secure, nonexploitable communications with submarines.

#### 4. Space Systems

The panel anticipates that the concepts of "freedom of space," "space control," and "space warfare" will be extended from maritime warfare into the space environment. A meaningful warfighting capability in space involving active systems (whether they must be invoked short of major war or not) and passive measures including hardening, "hiding," rapid replacement, countermeasures, and backup systems, will be essential to protect the Navy's ability to obtain surveillance and targeting information and to ensure information superiority over the USSR. The CNO will have to undertake urgent efforts with the other Services and non-DoD authorities to ensure the creation of the necessary space systems and the capability to protect them or replace them rapidly if they are taken out.

Agreements to eliminate ASATs (antisatellites) and weapons in space would limit the United States to the passive measures outlined, to insure availability of space systems or the functions they fulfill. Additional emphasis on those measures, probably including added resources, will be necessary to guard against violation of such a treaty, since the violation might not become evident until a time of wartime stress.

#### 5. Undersea Systems and Forces

The panel believes that in the long run submarine advances will make ASW increasingly difficult because they will reduce the effectiveness of today's acoustic surveillance systems. The panel believes, however, that with continued emphasis on ASW systems and operations the United States can retain its advantage in this area.

The Navy will be able to create a new class of SSGN (nuclear guided-missile submarine), roughly equivalent to the OHIO class in size, able to carry and launch between 200 and 400 tactical missiles having ranges on the order of a few hundred to one or two thousand miles, depending on their design and purposes. Such a ship would expand the scope and capability of the undersea fleet to encompass many major missions in addition to those the undersea forces undertake today. The missions for such a submarine, in coordination with surface forces, would

include strike warfare, ASW (anti-submarine warfare) at long range, AAW (antiair warfare) at long distances from the surface fleet, ASAT launch, selective reconstitution of space assets, and mine warfare. It would be a major, multimission capital ship of the fleet, comparable with current surface forces.

Such a ship will require safe, secure, and unexploitable communication connectivity with other fleet and space units. The panel believes this will be possible and recommends early steps toward the creation of such a force, to hasten the attendant vast improvement in the Navy's ability to engage our most dangerous opponents.

Future submarines must be designed for greater survivability to hits (e.g., more compartmentation to contain the effects of weapon hits, hulls more resistant to penetration, and other measures), and our submarine weapons must be tailored to ensure destruction of Soviet submarine targets at any depth.

There is an opportunity to create a family of long-range, unmanned, underwater vehicles to undertake many undersea warfare missions. The "kickoff" effort should involve a group from many disciplines including a laboratory/industry team familiar with guided missile technology and able to apply that technology to long-range underwater system concepts.

The effectiveness of torpedoes in an environment of increasing submarine effectiveness will be a matter of increasing concern. Any torpedo program must also include attention to countermeasures against enemy torpedoes, especially wake-homers.

Mine warfare has been and remains one of the most underrated but effective forms of naval warfare. Current and future technology will offer the opportunity to design and deploy mines of reduced size with a diversity of hard-to-sweep triggering mechanisms. Companion advances in mine-sweeping and mine countermeasures capability will include improved mine-hunting sonars, use of precise navigation to "mark" and retain the locations of mines once found, and advanced means of sweeping mines or otherwise neutralizing them.

The resources currently devoted to mine warfare are small in relation to the potential effectiveness of the weapon systems, and especially in relation to the potential dangers that mines pose for U.S. naval operations. The panel believes that modest increases in resources in this area can yield very large payoffs for U.S.

maritime warfare capability, and that attention to defensive mine warfare will be essential to meet both Soviet and Third World threats.

Although the main undersea weapon platforms may operate at intermediate depths, surveillance and weapon envelopes must be extended from shallow to very deep. Knowledge of the ocean's characteristics, bottom terrain, and environmental conditions--"underwater weather"--at all depths and latitudes is essential for this purpose, and efforts to obtain that knowledge using all media (space, air, surface, subsurface) deserve very high priority.

## 6. Surface and Air Forces

The surface forces offer the unique ability to maintain a sustained and visible presence for deterrent purposes and for warfighting in many important circumstances, especially in the Third World. They provide the only way to project combat power ashore when there are no available bases and there is a need for heavy, sustained firepower and extensive ground and air forces. The surface fleet is able to connect rapidly and with least expense into the combat information network. It presents another dimension of threat to opposing forces, with consequent pressure on their resources. Finally, the surface forces are essential for support and protection of logistic, special operations, and commercial maritime activities, all of which use the surface of the oceans.

The panel believes that, given the importance and unique aspects of the missions the surface forces can carry out and the economic and engineering design imperatives that lead to consolidation of functions, the Navy will always have a significant force of large surface platforms of many kinds, with their associated aviation. This does not mean that the growing vulnerability of such forces will be overcome very easily. The protection of that force so that it can perform its missions will have to be inherent in the evolution of its form, the gradual redistribution and closer integration of its functions, and its connection with other maritime warfare force elements in space, on land, and under the sea.



The Navy will need aircraft carriers into the indefinite future. They will have to undertake many missions of deterrence and, if need be, combat against Soviet forces in maritime-connected situations. They will be needed to establish a strong military presence and to carry out protracted force projection missions in Third World crises, and they will make important contributions to protection of the sea lines of communication. While the carriers, with all other surface forces, will indeed become increasingly vulnerable to long-range and stealthy weapon attacks, from Third World as well as Soviet sources, new technology will offer the opportunity to alleviate these vulnerabilities. Advances will include improved countermeasures against surveillance and targeting, improved ship self-defense systems, and improved capability to strike against sources of anti-ship attacks. The panel therefore sees the surface forces' configurations and characteristics, including those of carriers, and the composition of the carriers' air complements, evolving to meet the growing threat in many ways.

The combination of vulnerability increases and the inadequacy of some technological solutions will encourage the migration of some currently carrier-based functions to new sea- and land-based platforms. These functions include, inter alia, destruction of shore-based air defenses, counter-carrier strike complexes, and other dangerous targets; surveillance and sensing for various ESM (electronic warfare support measures), and for AAW, ASW, and ASUW (antisurface warfare).

New technology offers means for long-range strikes against heavily defended targets using cruise missiles and ballistic missiles with maneuvering warheads. Vertical launch systems will permit high rates of fire to saturate enemy defenses. The long-range missile and launcher designs offer the opportunity to disperse extensive firepower to many other ships of the fleet in addition to carriers; ships could be designed to carry hundreds of such missiles within hulls of similar size to today's cruisers and destroyers.

Such ships could carry out anti-shore strike missions (as well as today's AAW, ASW, and ASUW) as a complementary force to the carriers, paving the way for the latter to deliver, in greater safety, the sustained firepower inherent in their order-of-magnitude greater weapon loads. These other surface ships would, of course, be subject to the same increased risks as the

carriers. They will benefit from the same force-wide protection measures and from the synergistic effects of complementary and cooperative combat actions of the entire force and its support. Loss of one of the smaller surface ships in combat would have a relatively lesser impact on total combat power than loss of a carrier, while the possible loss of a carrier will be made less likely by the presence of the increasingly capable smaller ships.

Thus the configurations of the individual sea and air systems and the integrated surface and air combat forces in maritime warfare are expected to change, gradually but significantly, over the time period of the study. The potential mixture of aircraft carriers, missile-launching surface ships, and missile-launching submarines imbedded within the REBM system signifies a redistribution of the main combat power of the fleet from its current unipolar configuration to a flexible triad of combat forces suited to a large variety of conflict situations against opposition varying from the USSR to diverse third countries.

Technology can also make available a very high-altitude, very long-endurance aircraft (which may operate in manned or unmanned versions) to carry sensors and diverse ESM. Such an aircraft will be useful for primary missions in AAW, ASW, ASUW, electronic surveillance, long-range line-of-sight communications, and other electronic support where continuous coverage is needed, and as a partial backup for space systems in the event they are temporarily or permanently disabled.

## 7. Weapons

The panel believes the Navy must make an early start on a next generation of long-range weapons. Two major weapon classes are visualized.

One would be based on a modular-design, conventionally armed cruise missile optimized for low cost and proliferation throughout the fleet. The panel hesitates to *specify* performance and cost figures but some illustrative numbers will be useful. The missile should be able to carry a 500- to 1,000-pound payload to targets 1,000 to 2,000 miles away. It should have reduced observables to the greatest possible extent; be launchable from submarine and surface ship VLS (vertical launch system) bays or launch systems or those they may evolve into; and from

aircraft; have midcourse guidance systems based on GPS (Global Positioning System) combined with inexpensive inertial; include the options of accurate self-contained guidance and terminal acquisition sensors for some missiles; and have warheads suitable for various targets and tailorable to those targets. Such a missile should be producible in very large quantities (tens to hundreds of thousands) with a target cost of at most \$500,000, and preferably much less for all but the special-purpose versions of such a system.

Technology will also permit the design of ballistic missiles having maneuvering warheads, with roughly the same physical characteristics as the cruise missiles, to permit use of the same launch systems as the cruise missiles. Ballistic missiles in such a size and weight class would, with current technology and design techniques, have shorter ranges than cruise missiles. Over the longer term, as specific impulse improves and design improvements over current systems, such as efficient staging, come into play, these missiles should come to have range-payload characteristics in the same general class as the cruise missiles. These weapons can be used for missions, including long-range strike, when rapid delivery is an important consideration. Modularity and low cost will be as important for this class of weapons as for the cruise missiles, and may be even more feasible. The two kinds of weapons would be complementary.

We believe that the weapons described and the cost ranges are achievable within the state of the art. Large numbers of these weapons will be needed for the dispersed firepower concepts described, to fill out the weapon complements and reloads for numbers of combat ships that are typical of the numbers in today's Navy, as well as the new SSGNs that have been described.

## **8. Amphibious Warfare**

The future world situation and potential U.S. concerns in the Third World will require continued emphasis in this area of warfare, which, with all its auxiliaries, currently demands on the order of 20 percent of the combined budget of the Navy and the U.S. Marine Corps. Revised employment concepts and rede-

signed forces will be needed to arrest the degradation of amphibious warfare capability against improving opposition.

The panel visualizes a two-tier approach. The first tier will consist of a lead echelon or advance force that is small, highly mobile, stealthy, and technologically very advanced. It will be able to operate autonomously or pave the way for larger, more conventional amphibious forces.

The more traditional forces will be able to function as a second echelon in medium-and high-threat landings, and as the main landing force in "low-end" situations. It will emerge from evolution of today's amphibious forces, but it will be more compact and lighter. Like the first-echelon force, it will use advanced technology to perform tasks now carried out by heavy sea and ground warfare systems, and its aviation will be based mainly on V/STOL (vertical/short takeoff and landing) systems. Both echelons will have to be integrated into the overall combat information and command networks and configured to take full advantage of the advanced fire support the future evolution of the fleet will make available.

The panel believes that the *technology* for forces of the kind described--special operations forces, advance forces, and redesigned "conventional" amphibious forces--will be available from the evolution of all the Service forces including the Navy. Attention and resources will be needed for creation of the special systems required for the particular kinds of operations described. There will not be many such systems, but their characteristics and configurations will be unique, and the Navy-Marine Corps combination will therefore have to create them. They will include the systems needed for landing and extraction of the special-operations and the advance forces; for command and control of all the amphibious forces and their fire support; and for help in sustaining positions in the process of carrying out their missions on land to the extent that systems for this purpose are not available from the Army, the Air Force, and the Navy.

An integrated Navy-Marine plan is needed for the evolution of the amphibious warfare forces.

## 9. Manpower, Training, Logistics

All future influences on strategic posture over the next 30 to 50 years point toward increasing system complexity combined with the need for long operational periods away from bases. Manpower (including men and women) for the fleet will be available, but high aptitudes will be in great demand. Training the requisite manpower and maintaining its proficiency will be expensive, and the panel believes the Navy will have to plan for a smaller, more mature and more proficient force whose members are retained longer in the Service. There will be a need for greatly increased equipment reliability and ease of operation leading to reduced manpower requirements (and consequent savings in training and operating costs), both for primary manning and for operations and maintenance.

Future developments in automation, robotic systems, and artificial intelligence will lead to significant enhancement of the performance of naval personnel through substitution of intelligent machines for people in tasks where it is desirable to do so--to save manpower, to perform complex tasks more effectively, and to perform tasks that are extremely hazardous. The manpower savings and improved effectiveness will continue a universal trend as technology, manpower costs, and availability evolve together. The reduction of hazards will occur in such areas as underwater and under-ice operations, amphibious warfare, and ship damage control and repair in combat. Movement in these directions will also gain more space for combat systems aboard ships, increase reliability, and improve readiness for combat.

There will be increasing opportunities to use advanced technology for training in equipment and system operation and maintenance. The technology will also include "embedded simulators" on primary equipment used in place on a noninterference basis during operations. This means of maintaining proficiency in the force will increase in importance as the capability advances and as the forces with their equipment and tactics become more complex. It will become increasingly possible and desirable to practice the operations of dispersed, integrated forces by using the actual equipment of the weapon and REBM systems to simulate and practice battle force operations in an operational environment.

Greatly increased reliability should help to alleviate logistic requirements for fleet maintenance away from home bases. Steps will also have to be taken to reduce the extent of replenishment of forces at sea. The panel foresees changes in power systems that reduce the need for underway fuel replenishment, and changes in weapon operating practices (such as return of major ships carrying hundreds of missiles in integrated launch bay systems to bases for reloading, and much more extensive use of guided weapons by carrier aviation to reduce strike tonnages) to reduce the need for underway weapon replenishment. In addition, there may be opportunities, based on ocean platform technologies well understood from the civilian economy, to establish temporary, movable bases at sea ad hoc in critical areas without the need for shore installations.

Changes such as those described above will not necessarily take place without considerable effort on the part of the Navy. The Navy will have to develop an integrated strategy, including allocation of institutional responsibilities for achieving this strategy, to make more effective use of people and to be able to operate effectively in the operational and technological environment the panel foresees for the twenty-first century. Planning for the changed manpower and logistic practices must begin with the initiation of the design of the primary systems and forces if the full benefit of the advanced technologies and associated operating practices is to be realized.

#### 10. The SSBN Force

The SSBN force will, in the panel's view, become increasingly important to the nation through the coming decades, especially in the event of a START agreement. Land-based systems are becoming increasingly vulnerable to attack while the sea-based strategic forces are approaching the land-based forces in capability against all types of strategic targets. The panel does not anticipate a serious threat to the survivability of the SSBN force in the foreseeable future, as long as the numbers of platforms are not significantly reduced. As indicated in connection with the tactical undersea forces, the general trend is for submarines to become less vulnerable to detection, and the modes of operation of the SSBNs will accentuate that trend for those

submarines. However, SSBN security will need continuing attention, and potential "point vulnerabilities" will have to be avoided.

### 11. Tactical Nuclear Weapons

The panel sees a need, both for deterrence and for war-fighting, to retain a *tactical* nuclear weapon capability at sea, with special attention to ASW and involving air, surface, and submarine launch of the weapons. In the areas of ASUW and tactical strike warfare, arms control considerations aside, there will be other ways of destroying most tactical targets, so that the need for nuclear means to do so may decline. The technical foundation for this belief lies in the anticipated combination of improved surveillance and targeting capability, improved weapon guidance, and improved conventional warhead design that future technology will make available. However, the deterrence value of tactical nuclear weapons at sea will remain important as long as the USSR (and possibly other countries, later) may field such weapons. There will be an opportunity to enhance the tactical nuclear deterrent by fielding sub-kiloton warheads coupled with precision guidance of the delivery systems, as a means of assured destruction of very hard targets with minimal collateral effects.

The panel believes that the Navy's posture with respect to nuclear forces, including force modernization with the above considerations in view, will need extensive attention by the CNO.

### 12. Resources

The panel's review, using representative numbers of major systems, suggests that the resources demanded for the systems and force evolution described above are consistent with the anticipated total renewal of naval forces over the next 30 to 50 years.

The mix of platforms, weapons, and information-related systems and the consequent cost structure in creation of the future Navy will change from those of today. Major new cost drivers will include the missiles that would be needed in very

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large quantities, the space systems, and the combat information/C<sup>3</sup>/battle-management systems. This will be true even though the Navy will share the costs of the space, information, and worldwide communication systems rather than pay for the entire systems from its own budgets. The resource allocation and management issues are the most critical ones facing the CNO in creating the future Navy.

### 13. Priorities

Following are the key action priorities implied by the results of this study. The order of listing should not be taken as a firm priority recommendation, but neither should the order be viewed as entirely accidental.

- The surveillance- and information-related systems, and ensuring connectivity among them and with fleet elements and commanders.
- ASW.
- Assuring the availability of militarily essential space functions.
- The signature-related technologies, pro and counter.
- Concepts for acquiring large numbers of cost-effective standoff munitions.
- Beginning the acquisition of new kinds of missile ships and submarines.
- Restructuring the amphibious forces.
- Manpower and its concomitants.



## 2

**THE FUTURE MARITIME WARFARE ENVIRONMENT****A. THE TECHNOLOGICAL ENVIRONMENT**

There will be many centers of technological advance in the non-Communist world. These are likely to include Western Europe and East Asia (paced by Japan), in addition to the United States. Moreover, scientific and technological advance in the Western civilian and commercial world will be as aggressive as in the world of national defense; many advances will appear or be exploited aggressively in the civilian world first, and there will be fewer cases in which advances in the military sphere will either exert the controlling intellectual/scientific/technical influence or be the dominant market force.

Further, there may be some heightening of industrially oriented development initiative in the Communist world, as evidenced by China's recent efforts and by the stated objectives of the Gorbachev regime, both for the USSR and for Eastern Europe. This may or may not mean that they can accelerate their rates of technological innovation, but it may well increase the efficiencies of the Communist economies and industries.

Altogether, therefore, the Soviets will have many centers of scientific and technical knowledge to draw from, and their ability to advance in areas of technology critical to Western security will not be as easily influenced by the United States and its allies as it was prior to the mid-1970s. The spread of technology to the USSR and its communist allies may well accelerate, with less lag between the application of technology in the United States and the West and its appearance in Soviet military forces. This trend will be reinforced by the demonstrated ability of the Soviets to field technology, once acquired,

more rapidly than we do when they decide it is in their interest to do so.

Other, related developments include the appearance of threatening technology, especially that which can damage the surface fleet and sea-based tactical aviation, in Soviet- and Western-armed, supplied and trained third countries everywhere. Space-based global surveillance data may become commercially available to all nations (e.g., follow-on to SPOT, multi-spectral and high-resolution photography, SAR (synthetic aperture radar), mapping). At the same time, the interweaving of all the Western world's economies (in addition to the interweaving of their technologies) will make it much more difficult for the United States to mobilize rapidly, or to maintain the self-sufficient industrial strength to sustain a period of stress or conflict alone. The protection of the LOC (line of communication) to our allies and to overseas sources of supplies and manufactures will thus become even more critically important than it has been heretofore. Critical information about the state of the world's economy (including our own) as well as the instantaneous condition of the LOC, with consequent potential for disruption, will also be common throughout the world.

The relationships among the United States and its close allies in Europe and Japan will evolve, as economic competition and cooperation interact with military developments on the world scene. New, regional political power centers are likely to emerge in, for example, South and Southwest Asia, the Far East, and Latin America. China could well emerge as another major, modern industrial and military power during the next 50 years. These developments will make it more difficult for the United States to establish and pursue straightforward policies like the system of alliances of the 1950s through the 1970s aimed at "containment," and will provide additional sources of instability and technology transfer as the new powers vie for markets and political position.

Oil could become scarce in the civilian economy toward the end of the time period of interest, although enough is expected to be available to fuel the armed forces, per se. This could give the United States and its allies an advantage as new energy sources that we control, or for which we are better placed to devise and sell the technology, come into play (e.g., coal, uranium, tar sands, shale, natural gas, hydrogen). Such develop-

ments would alleviate current sources of friction, e.g., Southwest Asia; or, they could exacerbate political and economic stress as multiple industrial powers vie for what is left in the oil-bearing areas.

However the economies and political alignments in the world develop over the next 30 to 50 years, U.S. maritime forces are likely to have to spread their attention more globally. But shifting political tensions may make the overseas base posture available for all U.S. military operations, including those of the maritime forces, even less secure for use in all contingencies than it is today. Thus, U.S. maritime power is likely to become increasingly important to this nation's general strategic posture, and its radius of effectiveness must be increased substantially. If our overseas base and alliance structure become less secure, the Navy will tend to become an increasingly important part of our forward deployment. If they remain secure, maritime forces will be needed to protect the LOC with them.

## B. SOVIET DEVELOPMENTS

The Soviet Union will be protecting its land mass while its targets will be distributed across our LOC, our homeland, and those of our allies. The Soviet Union can be expected to tailor its maritime warfare forces and its operations to this target structure, which is the obverse of ours.

To attack us in these many areas, the Soviets will continue to give strict attention to global surveillance, C<sup>3</sup>, and their combat information networks. Through redundancy of modes of observation and communication, and use of diverse parts of the frequency spectrum, they will make these elements of their command and information systems very sturdy. At the same time, they will continue to concentrate on, and will improve, their radio electronic warfare, countermeasures, cover and deception techniques, and other ways to counter our surveillance and targeting systems. They will keep building space systems that are flexible in operating modes and have extensive rapid launch and replacement capability; the military characteristics (i.e., hardening, etc.) of their systems will be prepared for space warfare. This will be an area of concentration for them, as it

has been heretofore, and they will have the potential for many surprises in space.

The Soviet Navy is expected to continue to emphasize undersea warfare, while their overall maritime warfare forces will include long-range, land-based aviation, as they do today.

They will give strong attention to attacking our surface and submarine naval forces, with special concentration on submarine-launched cruise missiles and torpedoes, and on cruise missiles launched by the land-based aircraft. They are likely to take increasing advantage of low-observables technology and also to use high supersonic speeds for their missiles as an alternative; both will be designed to minimize warning and engagement time. They will also continue to make great advances in undersea technology and warfare, with attention to quieting, ability to integrate and coordinate the activities of their undersea forces, and diversity of weaponry on their submarines.

The Soviet surface fleet and its overseas base structure will be developed further. While these developments may continue to have the primary purpose of covering and protecting their undersea force operations, the surface fleet will enable them to establish a presence in key areas as world political developments and opportunities dictate, and to attempt to influence the outcomes of Third World crises. The possibilities for U.S.-Soviet naval confrontations in regional conflicts may well increase.

Historically, the Soviet Union has lagged behind the United States in most areas of technology but has acquired the advanced technologies eventually. However, in some important areas they have been the first to field systems that exploit militarily a technology that appeared first in the United States or the West. The overall historical pattern is expected to continue. The time lag in Soviet applications of technology will sometimes be large, sometimes small; it will depend on their ability to emulate us as well as on their perception of need to use U.S. and Western technology to achieve their objectives. Many of our technologies will appear in their maritime warfare forces, although they may be used differently in many cases. The times at which they will appear will continue to be variable and unpredictable; often the time lag will be uncomfortably short, especially in the future environment of globally spreading Western technology.

### **C. FORCES THAT WILL SHAPE THE NAVY OF THE TWENTY-FIRST CENTURY**

The Navy of the twenty-first century will be shaped both by technology-driven forces that move it away from current forms and systems, and by technological opportunities to solve mission-oriented problems, helping to carry out maritime warfare missions more effectively.

#### **1. Future Technology-Driven Pressures Away from Current Systems and Forms**

The first such problem is the increasing vulnerability of surface ships, aircraft, and spacecraft to detection and attack. Anything on the surface can be seen by the Soviets using their global surveillance system, and attacked by them from submarines, air, or even their surface fleet, depending on the particular geography and situation. The attack systems will have increasing reach and impose shorter engagement times for most U.S. weapons. Moreover, the Soviets will help others, with intelligence, surveillance data, weaponry and training; the systems they provide will be increasingly capable. Also, ship attack missiles, many stealthy, will be rampant in the Third World. They will be spread around the world by the West as well as the Soviets. As we have already seen, both in the South Atlantic and in the Persian Gulf, these can be used with telling effect by military forces that are not necessarily very capable overall. And Third World forces can be expected to become more capable as time goes by.

Sea-based tactical aviation will face similar problems. Soviet air defenses of increasing sophistication and capability will appear on their surface ships, in their land forces, and at the extraterritorial bases they use. Both they and the West will supply such air defenses to third countries, and carrier-based aviation could expect to encounter them in limited, regional conflicts as well as in war with the USSR. In addition, lasers of relatively low power, able in the absence of explicit countermeasures to blind crews and sensors on ships, aircraft, and weapons that they can illuminate, can be expected to be quite common in both Soviet and Third World forces.

Finally, our spacecraft may become increasingly vulnerable to Soviet ASAT and SDI-like systems if U.S.-Soviet military competition in the strategic-systems area heats up, or in the event of an extended conventional conflict.

The second major force that will move the Navy away from current naval forms is the pressure of resources. Resources to produce a diversity of defense systems are becoming increasingly scarce. Budgets are likely to remain roughly fixed (within  $\pm 1$  percent) as a percentage of the GNP (gross national product), as more claims are made on them. For example, the SDI and increasingly sophisticated C<sup>3</sup>I systems of all the Services have been added to already unmet demands for improvements and renewal in the major combat systems of the conventional and the strategic forces. There is no indication this will not continue to be a persistent problem. In this environment, the cost of major platforms (surface and air) is increasing rapidly as the tasks they have to do become increasingly complex in the above environment of increasing vulnerability. Moreover, manpower needs are changing as systems become more sophisticated. The costs of appropriately trained manpower will increase, placing a premium on reducing manpower used by the Navy (and the other Services) while equipment grows in capability and cost.

These two trends together mean that force sizes measured in numbers of platforms will likely decline, and overall force renewal to incorporate major technological change may occur increasingly slowly.

## 2. Technology-Driven Enticements Toward New Systems and Forms

The "explosive" advancement of surveillance, communication, and information technology that can be applied on a global scale will make it increasingly attractive and profitable militarily to improve the systems that find forces, locate and identify targets, transmit the information to combat commanders and forces, and guide weapons to the targets, many over very long distances. There is a close coupling of such technology to space, and its vital importance in the surveillance, communication, and navigation functions encourages the use of space systems for these purposes.

Continuous advances in missiles and unmanned craft, including their guidance, performance, stealth, and cost reduction (if we apply the technology for the purpose), will encourage the development of longer-range and more effective fleet-related airborne surveillance and targeting systems. Missile systems will extend the attack capabilities of platforms that are likely to stay in the forces longer. The combination of improved missiles and enhanced combat information systems will offer continuing opportunities for "planned product improvement" at the force as well as the system level.

Other advances that will offer the opportunity to solve the vulnerability and resource problems will occur in the areas of robotics, automation, and advanced guidance and control systems for unmanned aerial and undersea vehicles. "Intelligent machines" can reduce manpower and improve combat damage control and shore- and ship-based fleet support. RPVs (remotely piloted vehicles), UAVs (unmanned aerial vehicles), and AUVs (autonomous undersea vehicles) will be able to carry out many missions under many circumstances that will reduce the need to put manned ships and aircraft at risk.

All these advances will offer the opportunity, and the limits on resources will present the need, for new ways to deliver decisive numbers of weapons on targets, from dispersed formations, with economy of force and reduced attrition.

## 3

## KEY TECHNOLOGIES

A few technologies will, in the opinion of the panel, become the most important influences over the form and functioning of the Navy and in the preparation for and exercise of maritime warfare over the next several decades. What follows is a summary of these "drivers," selected from the reports of the various technology study groups and special projects.

1. Modern electronics applied to navigation and position location; weapon guidance systems; sensing for surveillance, reconnaissance, target location, and acquisition; data processing; fusion of information from many sources and its evaluation; computing and use of computers for pattern recognition and inference; diverse displays and aids to command and control decisions; and communication of any or all of the information and the decisions to users as necessary and desired without providing the enemy with targetable sources.
2. Stealth and counter-stealth technology integrated with electronic warfare capability such that, when used in integrated fashion, the combination can prevent a potential enemy from sensing friendly systems and activities, or, if reduced or masked signatures embedded in noise are sensed, from understanding the meaning of the data or the combat situation, while overcoming these disadvantages for friendly forces.
3. Application of advances in the above two areas of technology to unmanned aerial and underwater vehicles and systems for various missions from air and underwater surveillance and reconnaissance to covert



unmanned, lethal aerial weapons, and to emplacement and control of unmanned underwater weapons at distances up to hundreds of miles from the launch and control points.

4. Automation, robotics, and associated use of computers in artificial intelligence modes--intelligent machines--are just entering the civilian economy as drivers of efficiency and high orders of quality control in all areas of manufacturing, many other industrial processes, transportation, and the logistic and support adjuncts to transportation. These capabilities will substitute for people in certain tasks; they will allow people to perform tasks better than they can perform them now; and they will enable performance of tasks that people now cannot perform. Applied to the design and operation of ships and shore facilities, this area of technology will provide the opportunity to make much more efficient and effective use of the manpower available to the Navy, to improve training and to reduce training time, to design ships with faster and more certain responses in damage control, and to enable more rapid turnaround and reloading with concomitant time and cost savings, especially in time-critical situations.
5. Supporting technologies will enable advances on a broad front in space, air, surface, and subsurface systems, including weapons, platforms, and the essential means to tie them together and direct them. The most important of these are:
  - a. Advances in weapons, including advanced non-nuclear kill mechanisms that could increase warhead effectiveness by up to a factor of four, and sub-kiloton nuclear warheads.
  - b. Advanced weapon propulsion, including rocket propellants that may, over the time period covered by this study, achieve a factor of two or more improvement in specific impulse, and closed-cycle power plants for undersea weapons and unmanned vehicles that will greatly extend their range.

- c. Aeronautical technologies, including advances in aerodynamics, propulsion, and structures, all of which enhance the effectiveness and operational radius of airborne platforms, and particularly those with V/STOL capabilities.
- d. Ship technologies, including changes in power plant and power transmission system design (including electrical power transmission), internal hull design, major concept variations in hull form, and integrated weapon and weapon launch systems.
- e. Communication technologies, sturdy to disruption by either natural forces or enemy countermeasures, to insure connectivity of surface, air and space elements of the Navy with each other and especially with undersea forces and systems.
- f. Advanced communication network architectures and information processing systems, including software advances, to insure effective and reliable passage and utilization of information.
- g. Use of photons as well as electrons--e.g., lasers, optical processors, and optical transmission lines--in sensing, processing, and transmission of information.
- h. Accurate timekeeping, which leads to the possibility (already arriving) of a few feet accuracy in position location in a worldwide Global Positioning System (GPS) grid; this, in turn, will affect force movements, target location, weapon guidance, and command and control, and in consequence have a major impact on all maritime warfare.
- i. Underlying all the above advances of technology will be advances in the science and processing of materials, including higher-temperature superconductors, low-loss fiber-optic cables, composite materials for structures, materials such as gallium arsenide for advanced electronic circuits, and others.

These technologies and their implications are described in more detail in the reports of the individual study groups and special projects that constitute the later volumes of the full report.

## RADIO-ELECTRONIC BATTLE MANAGEMENT AND THE INFORMATION NETWORK

The panel used the term Radio-Electronic Battle Management (REBM) to encompass the functions of intelligence, surveillance, and reconnaissance; command, control, and communications; all technical operations on information; electronic and electrooptic warfare coupled with signature management or "observability warfare;" and targeting. We believe that radio-electronic battle management must be treated as an organic whole to ensure success in the "information war" with the USSR. Radio-electronic battle management begins with global surveillance capability and ends with force engagement using all available means for targeting enemy forces and preventing them from targeting ours.

Global surveillance signifies on-demand surveillance of selected geographical areas, where needed, when needed, for as long as needed, coupled with periodic surveillance of all areas and the ability to focus on a point of alert. The global surveillance system includes a multiplicity of sensors in several sensing regimes across the frequency spectrum. The sensors "report" at many levels from national to local; some are organic and some are off-board, for each level. They are based on diverse platforms including spacecraft, high-altitude, long-endurance aircraft, and all the tactical platforms of the fleet--ships, aircraft and submarines. Land-based over-the-horizon radar and distributed undersea sensing networks are also included. The global surveillance system will always exist in some form, as it does today. It will include more new and improved sensors as the technology makes them available and as resources permit.

Within the Global Surveillance System, it should be possible to retain all-weather, high-resolution, accurate position data on fixed objects (in mapping and target sets) with updates as often

as needed. This capability is being approached today. Moving objects will require specification of design parameters such as a revisit time, resolution, and coverage. These parameters will be variable with situation and operational needs, and physical limits will affect them. For example, fixed or usually static but relocatable targets may be the easiest to locate. Slowly moving targets on the surface could, depending on the circumstances, require greater concentration of resources. And, tracks of low-observable, moving aircraft may always require added resources to fill gaps in coverage from space.

Continued attention will be needed to maintain our undersea surveillance advantage. In addition, the growing importance of undersea warfare will require enhanced connectivity with and among undersea forces. Such connectivity will not necessarily always have to be two-way (indeed, there could be a trend to less two-way communication even within surface and air forces in a persistent EMCON [emissions control] environment) but the option will have to be there to be invoked whenever tactical situations dictate.

The global surveillance systems will be integrated with a combat information network serving Navy force commanders, fleet and regional CINCs for intelligence, targeting, and combat command and control. Using modern communications and computing technology the combat commander will have information of global scope at his fingertips, and he will be able to command his forces at ranges beyond any contemplated today.

In the network the sensors will feed multiple processing, evaluation, and command nodes afloat and ashore, at various command levels, with extensive redundancy for sturdiness to disruption. The nodes will furnish information to users at all levels by reports, alerts, or simply on call, in a flow that is managed to prevent saturating the users. The information flow will be variable in volume, quality, and responsiveness according to users' needs in peace, crisis, or war, and it will use a communication network that transmits in many modes (e.g., satellites, ionospheric or meteor-trail bounce, UHF) at many frequencies from laser frequencies to EHF, and in media as diverse as radio and fiber optic cable, as suited to specific situations and needs and designed to deny countermeasures and hostile exploitation.

A network of this kind is being created today, and many elements of it exist. It is essential to accomplish its full develop-

ment over the next 30 to 50 years, with appropriate application of resources.

## 5

**EXPANDING BATTLE SPACE, FORCE INTEGRATION,  
AND LOW OBSERVABILITY**

The general expansion of the battle space in the years since World War II included continually increasing reach of individual combat units, enabled both by their increased performance and by radar and IR detection technology. This trend will certainly continue. Concomitant with this trend, the fundamental combat system of the Navy has gradually changed from the individual combat ship to the combat force operating under, on, and over the water and in space, including submarines, surface ships, aircraft, spacecraft, and supporting forces and subsystems whose reach or influence covers radii of thousands of miles, all carrying out specialized, mutually supporting functions.

This evolution is not yet complete. Today's force-wide combat system is as yet imperfectly integrated as a whole, although parts of it, such as carrier battle groups, have achieved a high level of perfection in force integration.

The future will see continued extension of the reach, scope, and level of integration of all elements of the combat system as a matter of necessity. Dispersal will be required to make it more difficult for enemy forces to target our maritime warfare forces in a coherent and concentrated manner, and also to reduce the signaling of aggregated forces' target areas. Long-range weaponry will permit concentration of firepower from widely dispersed forces, while broad-area surveillance and the near-real-time integration of information from many sources within the REBM system will make possible the associated targeting and coordination of the activities of the force elements.

At the same time, the terminal combat radius of defensive systems will decrease in the future. Low-observable technology--including air- and submarine-launched weapons--will

shrink the battle space of individual combat units. Each unit will need its own terminal defenses, much stronger than are those in use today. Such defenses will be much more effective if they are alerted and informed about oncoming threats by the overall combat information system that can glean, integrate and interpret information about stealthy threats from broad observations in various parts of the spectrum. Thus, enhanced local defense will also require increasingly tight and complex integration of the information system linking all the elements of the entire combat force to maintain and extend the overall gains in reach and influence of that force.

Therefore all Navy weapon systems and platforms will have to be embedded in the extensive and sturdy combat information network, to ensure the ability of the force elements to operate together as a total combat system, to preserve stealth and to reduce vulnerability. The need for integrated operation of such systems led to the REBM concept articulated in the previous section. The combat information network will be operated partly by the Navy and partly as a national and multi-Service set of systems in which the Navy will have a major share for command, control, and utilization of the assets.

Both the United States and the USSR face the need for such a system. The interaction between the two will constitute the contest not only for information advantage but for force and combat advantage as well.

As part of this contest, all future Navy forces, systems, and vehicles will have to be built to take advantage of the capability for management of signatures (i.e., reduce, alter, enhance, and orchestrate)--of the force and all its elements--to deny enemy targeting; to be able to penetrate enemy defenses; and to deny the ability of low-signature enemy systems to be effective against our defenses.



## SPACE SYSTEMS

The growing importance of space to all powers will involve space systems in any maritime conflict. Major parts of the systems for surveillance, navigation, weapon guidance, targeting, environmental forecasting, mapping and geodesy, and communication will be based in space. Whether elements of these systems are uniquely vulnerable or not is a crucial question. The USSR may be no more anxious than the United States to invite destruction of its space assets by attacking those of the United States, but it will decide whether to attack them based on its own assessment of the balance of gains and losses. Other powers could develop ASAT capabilities during the time period we are examining. The United States must thus be prepared for such an attack, whether we think it likely or not.

The panel visualizes that over the years a number of concepts with which we are familiar from the maritime environment are likely to be applied to space and to become elements of international law and conflict with which the Navy will have to be concerned. These concepts include the following:

- Freedom of Space: open access to space by all nations, subject only to frequency allocations and other noninterference agreements; physical interference with another nation's satellites would be forbidden, but nondestructive electromagnetic interference may be "allowed" under conventions governing declared war between nations.
- Space Control: the ability of a nation to assert dominance over the existing space systems of others or their freedom to deploy space systems during war or stressful

conditions leading up to war; this will include destroying enemy satellites, related ground facilities, and ASATs.

- Space Warfare: use of space-based target acquisition systems and weapons to attack military and civilian targets in space, in the air, or on the earth's surface or under the sea--i.e., unrestricted military use of space.

Future technology will increasingly enable implementation of any of these concepts. This will affect the design of space-based parts of the REBM system, in order to protect the functions those parts of the system provide. Protection of the space-based functions on which the Navy depends will include such measures as follows:

1. intrinsic hardness to directed energy weapons, counter-measure resistance, decoys, and maneuverability to evade ASATs;
2. reduced vulnerability of the terminals (a critical and neglected problem area), through redundancy, dispersion, mobility, and more autonomy for assets aloft;
3. capability for rapid replacement of space assets, through land and sea based surface launch, and through deep-space storage of silent spares;
4. ASAT and counter-ASAT systems, which the panel views as essential for deterrence, for eliminating enemy threats to our systems if they appear in operation, and for eliminating enemy systems if necessary in time of active conflict; and
5. backup systems, that may or may not be based in space, for communication, surveillance, navigation, targeting, and support of weapon guidance.

Since the Navy will depend, into the indefinite future, on many space assets it does not control, ensuring the functionality and security of the space systems on which it depends will be a key and continuing problem for the Navy. It will increasingly have to be concerned about the freedom, control, and use of space in warfare. It may become an active participant in space warfare. The Navy will have to account for the multi-Service

and multi-agency nature of space in planning and implementing the REBM system; much of that planning and implementation will take place in the joint environment. Interaction with the SDI and its management structure, however the latter may evolve, can be an important element of this activity.

Agreements to eliminate ASATs and weapons in space would limit the United States to the passive measures outlined, to ensure availability of space systems or the functions they fulfill. Additional emphasis on those measures, probably including added resources, will be necessary to guard against violation of such a treaty, since the violation might not become evident until a time of wartime stress.

## TACTICAL UNDERSEA WARFARE FORCES

### A. SYSTEMS FOR MARITIME WARFARE FROM UNDER THE SEAS

Submarines with increased capabilities could become major, multimission capital ships of the fleet, representing a further step in the evolution of naval warfare systems from the old ship of the line through the battleship to the aircraft carrier. This will be driven by the need to reduce vulnerability of forces that must be prepared to engage Soviet forces, and by the opportunities offered by advanced missilery and quiet submarine technology (as presaged by and embodied in the technology of the SSN-21 [nuclear attack submarine] and the SSBN [nuclear ballistic submarine]).

It will be possible, provided appropriate targeting and communication systems for battle management are created, to build a new class of SSGN, of a size between that of an SSN-21 and an OHIO class SSBN. Such an SSGN could, on a single mission, carry and deliver between 200 and 400 tactical cruise missiles or ballistic missiles over ranges of several hundred to as much as 2000 miles. Such ships could deliver extensive effective firepower in strike warfare, in a campaign where a high-threat environment precludes protracted time on station for the surface fleet. They would use an order of magnitude fewer people and remain far less vulnerable to early detection and counterattack than the surface force. They could, in coordination with surface forces, destroy local and area defenses ashore and offensive systems threatening the surface forces, enabling the latter to engage subsequently in protracted campaigns when the risk of severe attrition has been lowered.

Other missions for such a submarine include ASW at long range; ASUW; AAW at distances from the surface fleet where incoming bombers would be accessible to long-range "forward-pass" missiles before they can launch their own missiles, and where the submerged AAW ships would not be nearly as vulnerable to detection and counterattack as surface combatants in such positions; ASAT launch; selective reconstitution of space assets; and mine warfare.

New systems for undersea warfare may include autonomous undersea vehicles (AUVs), submarine-launched, unmanned aerial vehicles (UAVs), longer range torpedoes, and advanced technology mines. Such capabilities would create the potential for new kinds of weapon systems to be operated by attack submarines. Armed reconnaissance by submarine-launched weapon systems would become possible, and the systems could become important adjuncts to active and passive ASW.

Such evolution of undersea warfare forces and missions will require more continual contact and more extensive linkages with the REBM system than exist now--for targeting against surface targets (on land as well as at sea); for signals to launch missiles to which final target position and track information may be transmitted from surface, airborne, or space systems; for coordination and integration of undersea, surface, and air operations for counter-ASW and diverse surface warfare purposes; for coordination of multi-submarine operations in major campaigns; and for protection against detection at critical times when communicating or launching weapons.

While use of submarines in the modes described can present additional risks, many critical target locations will be known in advance. Target locations, tracks, and launch signals for "forward pass" missiles can be transmitted by one-way communication with minimum response to indicate receipt of and action on the information. The extent of report-back and battle-management/C<sup>3</sup> communication for fleet-wide coordination purposes can often be controlled as to amount and timing, to reduce vulnerability to detection. All these measures, together with the use of LPI communication in new modes that advancing technology will make available, can minimize the additional dangers that might be posed by the enhanced connectivity.

## B. ANTISUBMARINE WARFARE

Continuing advances in submarine quieting will gradually negate today's broad-area passive acoustic surveillance systems. Other methods will become more important for finding submarines.

The panel anticipates that there will be no clear winner in the ASW measure versus countermeasure contest, but over the long run the submarine's advantage in evading ASW techniques and systems will increase. We believe that by heroic efforts the erosion of U.S. capability in ASW against Soviet (and third-country) submarines can be slowed more effectively than that of our opponents against our undersea forces. Retaining this advantage will require significantly more attention and resources for R&D and system acquisition and operation than have been customary in the ASW area.

## 8

**SURFACE AND AIR FORCES****A. SURFACE AND AIR WARFARE SYSTEMS**

The combination of increasing vulnerability of the surface forces, their increasing cost, and the growing target engagement capabilities of other forces raises the question of whether most of the missions of maritime warfare cannot be carried out by a combination of land-based and submarine or submersible forces. Technically this possibility may exist, but there are many reasons to retain and improve the surface naval forces.

1. The ability to respond rapidly in time of crisis, especially in regional conflict situations, and to maintain sustained and visible presence for deterrent purposes, with minimal dependence on foreign bases, is much greater for a surface fleet than for either land-based army and tactical air forces or for a largely undersea and land-based maritime warfare force, or even for combinations of these other alternatives.
2. The surface forces offer in combination the unique ability to project and protect power ashore when that power includes combined land and tactical air combat forces of any significant scale.
3. The ability to connect with the combat information system rapidly by a large variety of means and the ability to launch weapons in rapid fire are all easier and less expensive from surface ships than from ships configured primarily for underwater operation.
4. Surface forces present another major dimension of threat for opposing forces, especially the USSR, to deal

with, complicating their own maritime warfare strategies and forcing them to spend much more on that area of warfare than they would otherwise have to.

5. Much logistic and special warfare support uses the surface, in addition to combat forces. Protection and operation of this support requires surface combatants.

The surface and air forces of the fleet are likely, however, to be induced by the factors of vulnerability, cost, and technological opportunity described previously to evolve in many new directions.

1. Much more reliance will be placed on long-range guided missiles for strike and defense. This will include both cruise and ballistic missiles applied for tactical purposes against both land and sea targets.
2. Surface ships other than carriers, with their combat systems, may evolve into any of several different forms, or perhaps into several simultaneously. They are likely to become much more extensive carriers and launchers of long-range missiles than they are now. The missile guidance may use self-contained or the "forward pass" modes, and possibly both, depending on the economics and technological imperatives of missile and guidance system design including the targeting auxiliaries. While most surface-based missile-launching ships will probably be of familiar warship design, some could be made submersible, depending on future threat, engineering design, and economic considerations, while others could be based on amphibious assault ship design with missile bays in their well decks. The latter might be outfitted in more ad hoc fashion to meet emergencies; the combinations of ship types would seriously complicate enemy intelligence, command, and targeting problems in attacking the fleet.
3. Some ships will become bases (permanent or temporary) for sensors, including sensor aircraft, for surveillance and targeting within the battle-force area of influence--linked to and part of the overall combat information network. They may assume unconventional hull forms, such as variations on the SWATH hull, because



- such new forms appear to be better suited to the missions and associated equipment and systems.
4. We can expect to see much "cleaner" topsides for signature reduction; construction and materials designed to reduce damage potential in case of hits; more, and more varied, point defenses to protect these increasingly valuable platforms against "leakers"; and much more automation in operating systems to save manpower and to ensure against errors in operating increasingly complex combat and control systems.

The panel believes that the Navy will need aircraft carriers into the indefinite future, for the reasons outlined above for the surface fleet in general. The carriers' configurations and the shapes and composition of their air complements will evolve in a pattern set by the growing capability of potential opponents including Third World countries and the Soviet Union, by the opportunities of new technology, and by the new systems these factors induce. In particular, the increasing vulnerability of surface ships to long-range and stealthy weapon attacks will require changes in carrier aviation and migration of some carrier missions, including, inter alia, destruction of air defenses and attack systems threatening the carriers, surveillance and sensing for AAW and ASW, and various ESM, to alternate sea- and land-based platforms.

Carrier aviation will then be able to concentrate more on missions that require sustained delivery of weapons over long periods--their weapon loads permit mass and sustainability an order of magnitude beyond the capacity of even ships and submarines specifically configured to carry large numbers of long-range missiles. Carrier combat aviation will incorporate stealth technology extensively, and it will use guided weapons much more than it does today. Many of those weapons will be capable of delivery from long standoff. Such system evolution will enable target destruction with greater efficiency, involving fewer sorties and reduced attrition of these expensive systems, per sortie and in a campaign.

The support elements of naval aviation, including supporting carrier aviation, will also incorporate stealth technology extensively to enable them to operate effectively in the environment of the combat aircraft and the missile-launching surface ships.

They will search out enemy forces, provide ESM, contribute parts of communication systems such as relays, provide midcourse and terminal target information to long-range missiles, and back up or supplement space assets. While many such missions may be fulfilled by long-endurance land-based aircraft, the characteristics of third-country operations may encourage smaller versions of such aircraft to operate from carriers. Such aircraft, if they are of the V/STOL variety, would also be able to operate from ships other than carriers, and some small carrier configurations may evolve into staging and refueling "bases" for them so that they can move freely about the dispersed fleet formations with only periodic need to return to their primary bases on the large carriers. Some of the aircraft in these missions may be unmanned; all ships would be able to launch, recover, and refurbish unmanned aircraft at some level of size and complexity.

The evolution of the aircraft carrier will include sufficient attention to signature management of these large ships, in addition to the signature management of the smaller ships and of ships that resemble cargo or merchant ships, that identification and targeting by opposing space and aerial reconnaissance systems should become more difficult than it is today. Such signature management may include cleaner superstructures, creation of false radar signatures using other elements of the fleet and electronic warfare, and, of course, total or selective emission control (EMCON) together with more extensive use of off-board sensors and LPI communication links.

All ships will be required to carry and use major arrays of radio-electronic warfare, battle management, and force-related signature management systems to contribute to area defense against stealthy threats in the normal course of operations.

## B. ADVANCED AIRCRAFT

Improved conventional combat aircraft incorporating reduced signatures, enhanced performance, and "smarter" target acquisition and weapon control systems will serve wherever the environment permits the operation of an aircraft carrier.

High-altitude, long-endurance aircraft, while land-based, can be assigned or attached to at-sea forces and can provide sustained support in the areas of ESM, surveillance, AEW (airborne

early warning), ASW, ELINT (electronic intelligence), and other support such as communication relays and provision of navigation fixes and communication nodes to back up space systems. These may be unmanned, since time on station can be days rather than hours. A variation of this type of aircraft can support coastal protection and act as an SDI element. Using microwave power beamed from the surface to the aircraft on station--a capability that may well prove viable over the time period--the duration in this mode can be extended to years, limited only by the reliability of onboard systems.

V/STOL aircraft that have performance superior to that of helicopters will be able to operate from relatively small, aviation-capable ships in direct support of combat forces.

Unmanned aircraft serving similar purposes to many of the manned aircraft will have the advantages of reduced size, weight, and vulnerability. This will often compensate for the loss of flexibility attending the elimination of the pilot. Launch and recovery of unmanned aircraft at sea implies smaller ships and should result in lower costs while reducing the "at-sea" dependence on land-based aircraft. The concept of staging in which the very long-range, long-endurance, pilotless aircraft can be refueled at sea appears feasible, since the requirement for reduced ship superstructures for lower observable signatures will help aircraft with long wings use the decks.

The mix of manned and unmanned, sea- and shore-based aircraft, unconstrained by ideology, will emerge from the continual synthesis of mission requirements, costs, and operational considerations as the technology changes; it cannot be prescribed broadly in advance, but it clearly will change the way the Navy uses its aviation over the long-term future.

## WEAPONS

For each weapon system, as well as for the combat forces acting in concert, the means of targeting, the launch platforms, weapon delivery and guidance systems, and the warheads and their effects on targets, will all have to be designed together as an integrated combat system.

Within this general combat force design concept, the following elements, all of them existing in conceptual or early design stages today, are likely to assume sufficiently high importance that they will transform the shape of the maritime warfare forces and the way they operate.

### A. CRUISE MISSILES AND BALLISTIC MISSILES WITH MANEUVERING WARHEADS

While long-range guided missiles will not totally replace guns, air-launched bombs and other weapons that may be developed, and their importance to strike warfare and ASUW will grow markedly, becoming comparable to their role in AAW today. Air-launched weapons in many situations of combat involving carrier-based battle forces will also require long standoff and appropriate weapon guidance because effective missile-based antiaircraft defenses will exist everywhere, and even relatively primitive forces will be able to blind direct attack systems with lasers of modest power. Much more extensive use of guided weapons will permit major economies of force in the use of aviation, acting as "force multipliers" to make the available sorties achieve more extensive objectives, in less time, than is possible today.

These considerations suggest that the Navy will be led to create a family of long-range missile systems for diverse applications. Two types should be considered, for different applications. The two kinds of weapons would be complementary. The modular designs described will permit upgrading as the technology changes, so that massive block obsolescence of the large numbers that will be needed can be avoided or at least postponed for long periods.

- One would be a modular-design, conventionally armed cruise missile optimized for low cost and proliferation throughout the fleet. The panel hesitates to specify performance and cost figures in a general study such as this, but some illustrative numbers will be useful. The missile should be able to carry a 500-to 1,000-pound payload to targets 1,000 to 2,000 miles away. It should have reduced observables to the greatest possible extent, be launchable from submarine and surface ship VLS bays or launch systems or those they may evolve into; and from aircraft; have midcourse guidance systems based on GPS combined with inexpensive inertial; include the options of accurate self-contained guidance and terminal acquisition sensors for some missiles; and have warheads suitable for various targets and tailorable to those targets. Such a missile should be producible in very large quantities (tens to hundreds of thousands) with a target cost of at most one-half million dollars, and preferably much less for all but the special-purpose versions of such a system.
- Technology will also permit the design of ballistic missiles having maneuvering warheads, with roughly the same physical characteristics as the cruise missiles, to permit use of the same launch systems as the cruise missiles. The maneuverability of the warhead is important to attack targets of uncertain location in coordination with terminal sensing, or targets that may move during the time of flight of the missile (in ASW applications the maneuvers may take place under water). Ballistic missiles in such a size and weight class would, with current technology and design techniques, have shorter ranges than cruise missiles. Over the

longer term, as specific impulse improves and design improvements over current systems, such as efficient staging, come into play, these missiles should come to have range-payload characteristics in the same general class as the cruise missiles. These weapons can be used for missions, including long-range strike, where rapid delivery is an important consideration. Modularity and low cost will be as important for this class of weapons as for the cruise missiles, and may be even more feasible. The two kinds of weapons would be complementary.

The panel believes that the weapons described and the cost ranges are achievable within the state of the art. Massed use of such weapons must be contemplated to gain the combat advantages they will offer and to account for the inevitable waste induced by the uncertainties of warfare. Large numbers will be needed to fill out the weapon complements and reloads for numbers of surface combatant ships that are typical of the numbers in today's Navy, together with the new SSGNs that have been described.

For example, on the order of 200 DD- and CG-type combat ships and SSGNs of the kind described, each with a load of between 100 and 300 missiles, plus air-launched standoff cruise missiles aboard carriers, could lead to 40,000 or more missiles of various kinds at sea in the Navy of 2030. Test and training missiles, and reloads in storage, would lead to production numbers of over 100,000 missiles. The large numbers will, in turn, be essential for lowering the weapon cost. The more dispersed fleet, if its evolution proceeds as we have described, will thus gradually establish a new frame of reference for provisioning the fleet with expendable combat systems.

## B. POINT DEFENSES

Such weapons, including the ability to engage torpedoes as well as airborne targets, will become increasingly important as enemy stealth shrinks the defensive battle space of individual surface ships, including carriers. In addition to improved conventional point defense weapons, the capability to design

high-energy laser weapons and hypervelocity guns capable of firing projectiles at 3-5 km/second in packages small and light enough for shipboard use will probably emerge from the SDI and from the Defense Advanced Research Projects Agency (DARPA)/Service anti-armor programs. The technologies that make long-range underwater engagements possible will also contribute to enhanced defense against torpedoes, especially wake homers. All such weapons will allow proliferation of close-in defenses on individual ships - essential in the approaching era when many more attack systems may be able to evade the outer and area defenses of both combat ships and the LOC.

### C. DIRECTED ENERGY WEAPONS

Directed energy weapons (DEW) have been in various stages of R&D for many years and their development has been and will continue to be accelerated by the SDI. Such weapons will assuredly become technically feasible as alternative choices for several applications during the time period of concern in this study.

While charged particle beams for use within the atmosphere present some problems of physics whose resolution remains uncertain, laser and microwave beam weapons have already been proven feasible in several energy and target regimes. At various power outputs, these weapons will threaten sensors, electronic equipment and non-hardened materiel such as ship, aircraft, and missile elements within the atmosphere and in space.

Among the threatened "sensors" will be human eyesight, which is subject to damage at quite low power levels unless protection is provided. The Navy will have to create passive defenses against Soviet and third-country use of relatively low-power DEW to blind U.S. systems and people.

The very short "flight times" of higher-power beams suit such weapons well for use against the control systems and sensors of anti-ship missiles during their terminal attacks, subject to solution of cuing and target acquisition problems for beam pointing in adverse weather. These weapons may therefore become an important component of terminal defenses of ships and shore bases.

It will be difficult to harden satellites in low earth orbit against surface-based high-energy laser beams. With such weapons, the Navy can build at-sea ASAT defenses against early detection of surface ships by, e.g., radar satellites and other kinds of fleet location and targeting sensors in such orbits, provided that the statistical availability of favorable atmospheric conditions is acceptable.

This also suggests that the Navy and the other Services and agencies that provide detection capabilities and other space-based support will have to design the satellites and their on-board systems to operate at higher orbits, to be difficult to detect and to have at least some hardness in critical subsystems. The implications are that emitting systems will have to have LPI characteristics, radar or radar-like systems may have to operate in bi- or multi-static modes, and there will be a need for on-board attack detectors. All these factors will make for increased costs of space systems, and even though the Navy will not have to bear space system costs totally on its own this will add to the cost of the information-related parts of the Navy's overall combat system.

#### D. NUCLEAR WEAPONS

The panel sees a need, both for deterrence and for war-fighting, to retain a tactical nuclear weapon capability at sea, with special attention to ASW and involving air, surface, and submarine launch of the weapons. In the areas of ASUW and tactical strike warfare, arms control considerations aside, there will be other ways of destroying most tactical targets, so that the need for nuclear means to do so may decline. The technical foundation for this belief lies in the anticipated combination of improved surveillance and targeting capability, improved weapon guidance, and improved conventional warhead design that future technology will make available.

However, the deterrence value of tactical nuclear weapons at sea will remain important as long as the USSR (and possibly other countries, later) may field such weapons. There will be an opportunity to enhance the tactical nuclear deterrent by fielding sub-kiloton warheads coupled with precision guidance of the delivery systems. Such weapons can provide an assured kill



capability against major targets without many of the wide-area, collateral effects that currently accompany the much larger nuclear warheads that are in inventory. This does not imply any judgment about changing the constraints or conditions of use of nuclear weapons; only that if they are used, the Navy's ability to gain advantage from such use will be greatly enhanced by the advanced kinds of weapons described here.

## MINE WARFARE

Mine warfare has been and remains one of the most underrated but effective forms of naval warfare. It offers the ability, at very low cost, for a defending country to deny access to its waters for substantial periods; it also enables low-cost blockade to prevent an attacker from sending significant forces to sea, or to inhibit any nation from operating an LOC with significant flow of shipping. The USSR has given extensive attention to mine warfare, making it a significant threat area for the United States in a potential confrontation. It can be important to the United States in counter-Soviet operations should they become necessary, and can be especially important in Third World situations, both in denying United States and Allied access to important waters and resources and in helping the United States and its allies to contain actual or potential combat situations at relatively low cost. For all these reasons, the U.S. Navy cannot afford to ignore mine warfare forces.

Current mines (those of World War II and more recent vintage) are already difficult to locate and sweep. Future technology will offer the opportunity to design and deploy mines of reduced size with a diversity of hard-to-countermeasure triggering mechanisms. Companion advances in mine-sweeping and mine countermeasures capability will include improved mine-hunting sonars, use of precise navigation to "mark" and retain the locations of mines once found, and advanced means of sweeping mines or otherwise neutralizing them.

Thus the Navy can have available to it a class of weapons that in many circumstances yields payoff and operational flexibility far transcending the resources demanded. Conversely, there will be a strong need for mine countermeasures and mine

sweeping capability because mines may occur in a great diversity of major- and limited-war situations where, if the capability to overcome them rapidly is not available, the problems they pose can affect the strategic outcome of crises adversely.

## II

## AMPHIBIOUS FORCES

Amphibious forces will remain one of the major means for projecting integrated U.S. air-ground warfare capability ashore, especially where conditions preclude timely entry of Army and Air Force units. However, military opposition to landing of such forces will vary widely as to intensity and sophistication. As a consequence, traditional concepts of amphibious warfare will be seriously challenged. "High-end" opposition, such as may be encountered during a conflict on the NATO (North Atlantic Treaty Organization) flanks, will include the full panoply of Soviet response capabilities including rapid reinforcement to contain and attack landings. Similar capabilities--derived from Soviet or Western sources--are likely to exist in varying degrees in Third World areas where amphibious landings must be made. Total surprise in landings will be difficult to achieve, and direct assault against heavy opposition will be infeasible. These circumstances will induce a redirection of amphibious warfare force design and operations.

Amphibious forces will have to be designed to land with higher speed from more distant positions and from more dispersed fleet formations than are involved in today's amphibious warfare concepts. The greater standoff will make potential landing areas more difficult for opponents to anticipate and therefore to defend, at least initially, so that tactical surprise in amphibious operations will still be achievable. Higher speed and lower signatures will be required for landing forces.

Two complementary, fleet-based force configurations are visualized. The first are lead-echelon or advance forces that are well integrated with special operations forces to assist in initial, surprise

landings; that are light and highly mobile, but well equipped with the most advanced technology for calling in sea-based fire support; with advanced, lightweight anti-armor, antiaircraft and other small-sized, high rate-of-fire weapons to defend themselves. Such forces will be designed to operate against severe "high-end" opposition. They will be able to carry out independent operations whose duration will depend on the fire support and logistic support that can be provided to them in the specific circumstances. They will also have the mission of securing defense perimeters of substantial scope into which a second echelon of more conventional amphibious ground and air forces can then move if appropriate to take and consolidate strategically important positions.

The more conventional forces will be lighter than they are today, and will be able to take advantage of advanced technology that can protect them, provide heavy organic fire support, and allow them to take the offensive and occupy territory, all without the kind of heavy armored systems that the ground forces designed to operate in Central Europe will continue to need. These forces will also be able to operate against "low-end" opposition in much the same manner as today's amphibious forces.

Off-board fire support in both cases will be provided at long and short range by the more dispersed naval forces including both long-range missiles and changed combat aviation. Marine combat aviation will include some elements of the advanced systems that will evolve for carrier use. Thus, the reconfigured forces will incorporate versatility that today's forces will tend to lose as potential opposition advances in capability.

The amphibious forces will tend to use more nonhelicopter V/STOL aircraft than are used today, for all purposes. Landings at long ranges from start positions may be made from such aircraft, from vehicles based on Wing-In-Ground-effect (WIG), advanced LCAC or SES principles, or in some cases from submarines. Lift for the more conventional forces will be lighter and faster than today's (for example, the panel has visualized a fast, long-range assault vehicle that combines many of the advantageous features of both WIGs and LCACs). Attention to signature reduction will be needed for all forces, and the advance forces will have to be able to operate in highly stealthy modes.

All the amphibious forces will have to be integrated into the overall combat information and command networks as the latter evolve.

The basic technologies to support the reconfigured amphibious forces are available today, or will be available from the advances of all the Service forces in the future. Specialized systems, some of them noted above, will be needed to fulfill specific, unique requirements of the amphibious forces, at the special operations, advance and follow-on or main force levels.

## MANPOWER, TRAINING, AND LOGISTICS

The future Navy will need personnel (including both men and women, under the rubric of "manpower") having high skills for operation of the many advanced systems of the fleet and its adjuncts. The need for more training and a reduced manpower pool will lead to a more senior force than today's, with fewer people in the lower grades. The personnel will be available, but their cost will be very high. Offsetting savings have been anticipated, in Navy studies, from having fewer people and retaining them longer.

The prospect of having a relatively senior and more experienced, but less numerous work force carries implications for training and employing this force. Individuals will likely be farther removed in time from their entry and basic skill training. They will have to be refreshed and kept up-to-date. Technology will increasingly afford self-paced, computer-aided instructional courses for primary training and for maintaining proficiency. It will probably become necessary to use less specialized Navy technicians and provide them with computer-based support packages that will be hybrids between brief training courses and better maintenance aids. Recent tests with prototype equipment show that such packages can help improve the accuracy of maintenance and reduce the time needed to perform it.

Future developments in automation, robotic systems, and artificial intelligence will also lead to significant enhancement of naval personnel performance through substitution of intelligent machines for people in tasks where it is desirable to do so--to save manpower, to perform complex tasks more effectively, and to perform tasks that are extremely hazardous. The manpower savings and improved effectiveness will continue a universal

trend as technology, manpower costs, and availability evolve together. The reduction of hazards will occur in such areas as underwater and under-ice operations, amphibious warfare, and ship damage control and repair in combat. Movement in these directions will gain more space for combat systems aboard ships, increase reliability, and improve readiness for combat.

Operational systems, with their extensive use of computers, will embody simulation modes to permit training and proficiency exercises while under way. It is becoming possible to train complete crews without building simulators by using actual equipment at bases or during operations at sea, whenever this can be done without interference to an on-going mission. This can happen because most current and future operational equipments require various types of data processing components to handle external target signals and to maintain information on system status and equipment performance levels. The insertion of known and controllable artificial inputs and signals into such operational equipment offers crews and commanding officers an opportunity to practice and improve their skills in handling critical events such as equipment "malfunctions" or hostile "targets" that could actually occur at any time. Given improved, reliable control over the ability to switch operational gear from artificial to actual target signals, training can take place in the operational environment to fine-tune and maintain skills that are highly relevant to potential combat scenarios. This training can be extended to various force elements and the REBM system, so that it will become possible for battle forces to devise, learn, and practice tactics and related skills in close to a fully operational environment.

The embedded simulation techniques will obviously enhance readiness of the fleet. In addition, continued exercising in this mode will lead to system improvements that can be fed back into later system designs.

The need to spend long periods at sea in an environment where bases may be less available or less secure, together with the need for a smaller logistics tail to help preserve stealth and to reduce support resources, will make it mandatory to design for increased reliability and less manpower-intensive operation while deployed. Naval technology has been going in this direction since the transition from oars to sail, and another big jump may



impend, not only because people will be scarce, but for two further reasons.

First, the mediation of intelligent machines will, as noted, enable people to do more, and do it better. Second, the revolution in information technology makes greatly enhanced equipment reliability possible from a variety of directions. The design of new systems using CAD/CAM/CAE techniques can allow earlier and more economical intervention of reliability and maintainability considerations. Computers will greatly improve spare parts support, maintenance scheduling, and the like. Finally, there will be a vast improvement in maintenance support to the technicians who need it, in the form of readily accessible technical information, maintenance aids, historical and diagnostic information, easily updated technical and maintenance data, and better knowledge of likely faults, as well as virtually automatic ordering of spare parts and maintaining efficient inventories of replacement parts ashore and aboard ship.

Replenishment practices will also probably have to be changed. New power concepts, such as combined nuclear and gas turbine power systems (CONAG), quite analogous to the use of sustaining nuclear power with gas-turbine "topping" plants for peak loads in civilian power installations, might be found desirable to reduce the frequency of underway fuel replenishment in many combat ships. Ships designed with hundreds of missiles in missile bays might return to base for reloading when their missile loads are spent, much as submarines do when they have used all their torpedoes. Over the long term this would solve currently vexing problems regarding means to refill VLS bays while under way. Much more extensive use of guided weapons by carrier aviation will help reduce strike tonnages, also reducing the need for weapon replenishment at sea. An enhanced capability to deploy base facilities forward, using specially designed platforms much like large oil rigs, may well become attractive to support extensive and sustained forward deployments.

Changes such as those described above will not take place without considerable effort on the part of the Navy. The systems, concepts, and applications are not self-developing. In times of great financial stringency, vision and perseverance will be required to advance new technology that lacks powerful bureaucratic advocates and that, indeed, runs counter to currently

established institutional practices. The Navy will have to develop an integrated strategy, including allocation of institutional responsibilities for achieving this strategy, to make more effective use of people and to be able to operate effectively in the operational and technological environment the panel foresees for the twenty-first century. The issue is not one of technical risk because what has to be done and how to do it in the areas discussed is generally known. The drives within the commercial sector to develop improved reliability and less manpower-intensive maintenance and support practices will also lead in directions from which the Navy can glean useful technical advances.

However, to satisfy its unique needs in these areas, the Navy will have to develop a pro-active approach to the acquisition and application of the technologies (some forms of which have also been described in connection with undersea, surface, and air warfare systems) and the associated operational practices. **Planning for the changed manpower and logistic practices must begin with the initiation of the design of the primary systems and forces if the full benefit of the advanced technologies and associated operating practices is to be realized.**

## 13

## THE SSBN FORCE

The panel believes that the SSBN force will become increasingly important to the nation through the coming decades. Land-based systems are becoming increasingly vulnerable to attack while the sea-based strategic forces are approaching the land-based forces in capability against all types of strategic targets. In the likely event of a Strategic Arms Reduction agreement there could be a gradual shift of the strategic ballistic missile force to sea. In an environment that includes ABM defenses variants on the strategic ballistic missile submarines could be configured to carry strategic nuclear cruise missiles as an alternative means of defeating those defenses.

We do not anticipate a serious threat to the survivability of the SSBN force in the foreseeable future. As indicated in connection with the tactical undersea forces, the general trend is for submarines to become less vulnerable to detection, and the modes of operation of the SSBNs will accentuate that trend for those submarines. However, SSBN security will need continuing attention and potential "point vulnerabilities" will have to be avoided.

## NAVY INTERACTION WITH THE SDI AND THE ADI

The potential impact of the SDI on the technology that will be available for the Navy over the next few decades is a matter of special concern in planning the future of Navy systems and forces. Many capabilities that the Navy will benefit from and to which the Navy could contribute can be identified. They include the following:

1. Direct participation by the Navy in strategic defense of the U.S. homeland. The nature of such participation remains unclear at this stage of SDI/ADI planning. It is, however, possible to indicate capabilities that may become available and that may prove desirable to pursue. One possibility includes patrolling off the coasts, using surface ships, submarines, and aircraft in some combination to guard against and to intercept SLCM and depressed trajectory SLBM launches designed to evade the ABM defenses. Another possibility includes the launching of ABM missiles from submarines such as the tactical SSGNs described in the "forward pass" mode in coordination with space- and surface-based detection and battle management systems. In either case, extensive dedicated resources would be needed, and the relationship to the Navy's "normal" budget would have to be worked out.
2. Defense of surface battle forces against ICBM attack. If the USSR develops maneuvering warheads for its ICBMs and achieves advances in its own REBM system in many of the directions that we have visualized for the U.S. system, they could in some circumstances find

it profitable and feasible to target some of their ICBMs against major U.S. surface naval forces. If the SDI provides means to defeat ICBM attacks against land targets, or to defeat ICBMs in the boost phase, then the fleet will benefit as well.

3. Benefits to the national tactical maritime warfare capability, and to the Navy, via space control that the SDI will enhance. This includes the SDI contribution to global surveillance, defense of critical space assets, and the existence of a derivative ASAT capability in place.
4. Technology transfer in many areas. This involves most notably sensing and signal processing; computers and software; rocketry; materials; many parts of the weapons and countermeasures areas, including missile guidance and weapon-oriented directed energy in several frequency and power domains; and cost reduction techniques for space and missile systems.

## IMPACT ON U.S. MARITIME STRATEGY AND OPERATIONS

### A. NAVY MISSIONS

The missions of the Navy include the following:

1. strategic deterrence--defending the U.S. homeland;
2. sea control--to protect our sea lines of communication to and from sources of resources, manufactures, and allied military and economic power and to deny use of the seas to hostile powers when that is in the U.S. interest--strategic sea lift has been added recently as a related mission--and
3. power projection--projecting military power onto distant shores in time of crisis or armed conflict.

To achieve these purposes, the Navy undertakes a variety of subordinate operational missions involving many activities from maintaining "presence" to major military conflict, up to and including nuclear conflict, at and from the sea and, for the USMC, ashore. Such specific missions include strike warfare, AAW, ASW, ASUW, EW/ESM, amphibious warfare, mine warfare, and logistic support of the fleet.

These basic missions are not likely to change over the next 30 to 50 years, but the means for carrying them out will probably change significantly.

Whereas the carrier with its aviation currently represents the main element of tactical naval striking power, the technical capabilities and force elements described in the previous chapters will make possible a more fully balanced triad of long-range tactical naval striking power. The elements of the triad

are naval aviation; other surface forces with long-range missiles; and submarines with long-range missiles--all imbedded within the combat information network and its associated capabilities in the REBM system. The operating domains of the separate elements of the triad will be strongly overlapping, but each element will also be able to operate independently within its domain. The reach of the integrated, combined forces in each element of the triad, or of all of them in concert, will be measured in the hundreds to over 1000 miles for individual force elements. It will cover thousands of miles for major forces in dispersed formations.

The trend toward such a triad, together with movement toward restructured amphibious forces, is under way today, and the panel foresees its completion within the next 30 to 50 years.

## B. STRATEGIC DETERRENCE

The Navy will be able to contribute to the defense of the U.S. homeland in three ways:

1. by providing an essentially invulnerable retaliatory force based on SSBNs, as it does today;
2. by attacking (or being able and ready to attack) Soviet SSBN forces--future technology will enable our SSNs to use long-range, stealthy underwater systems such as "smart" torpedoes and mines; and
3. by contributing to the strategic defense forces, as described previously.

## C. SEA CONTROL

Protecting our linkages with allies and the overseas sources of our economic strength will require many approaches to dominating the seas:

1. neutralizing sources of attack;
2. keeping the sea lanes clear of threats;

3. denying effective maritime operations to hostile powers when that is in the U.S. interest; and
4. moving goods, and ground and air forces when necessary.

Although in the future more high-value cargo, and troops, may move by air, the sea will remain the main means to move large tonnages effectively. For heavy military forces the "driver" will be the weight of their equipment. For cargo, ships will be needed to move the tonnages that go with any sort of sustained war effort, and they will remain the most economical means to move bulk cargo in the civilian world. Fleet support by surface ships, while it may be reduced, will not be eliminated. And in many crisis situations overflight rights and airfields for major airlift may not be available in the early critical stages. The task of preserving freedom of seaborne movement in time of conflict will become increasingly difficult as time passes.

It will certainly include efforts to sanitize major ocean areas against threats both from the USSR (operating from interior and overseas bases) and from third countries that might attempt to interdict U.S. and allied shipping. However, advances in submarine quieting and stealth of airborne systems will make Soviet and even Third World forces more dangerous. The chances for successful evasion of U.S. and allied sea lane defenses by attackers will increase, and the threat to the SLOC (sea line of communication) will grow. Defeating or evading that threat will become more difficult.

Protective forces along the sea lanes, including the new kinds of surface and undersea systems that have been described, all operating with greater tactical connectivity and the other elements of the advanced REBM system, will have to detect and counter direct threats to shipping with increasing effectiveness. Our view of the evolution of such forces includes the anticipation that this evolution will indeed bring with it a large measure of the increased effectiveness.

Among additional steps needed may be changes in shipping practices, including less use of convoys that focus submarine fleet attacks; incorporating defenses on larger cargo ships that are at least sufficient to deter or defeat attacks by non-Soviet forces, and that can give a measure of protection against Soviet attacks as well; embedding important cargo carriers within the fleet so



that they gain the full benefit of the most effective fleet defenses; and direct use of naval forces for militarily vital sea lift. If the threat becomes severe enough it may become necessary, and the development of large submarines may make it economical, to plan, build, and use undersea transport of major, militarily important cargo in time of war or the threat of war.

Another approach to maintaining freedom from Soviet attack against the sea lanes is to deny exit of maritime-oriented Soviet air and sea forces from their major base areas in the northeastern and the northwestern USSR, as well as through various other choke points. This can be approached by a combination of attacking the bases and establishing ASW barriers across restricted straits and narrow ocean areas.

As the barrier ASW problem becomes more difficult, base attack will become more attractive. In addition, base areas that the Soviets are establishing outside the USSR, on warm-water shores, are targets for attack and destruction in case of conflict with the USSR. Today, the main burden of such attacks must be borne by the carrier forces. In the longer-term future, the new kinds of undersea forces described above will be able to deliver effective destructive power with total surprise, at less overall cost and from much less vulnerable postures than today's forces can achieve. There will also be a more versatile capability deriving from the dispersal of major firepower through the fleet, to neutralize land-based threats against the sea lanes from third countries.

#### D. PROJECTING POWER ASHORE

Power projection includes attacking targets ashore from the sea, and landing air and ground forces to destroy enemy combat forces and take territory when necessary and feasible. The panel foresees that surface forces will remain the primary means for projecting power ashore in areas where warfare with the USSR is not directly involved. And, they will be able to exercise not-inconsiderable military power against Soviet forces as well, especially in situations where they are not exposed to full Soviet offensive maritime warfare capability, such as engagement of major bases outside the USSR.

Seaborne tactical aviation based on aircraft carriers will continue to provide flexible, responsive, and sustained firepower in situations where the ships are not extremely vulnerable to land-based and sea-based counterattack, and where their aviation can operate at low anticipated attrition levels--in particular, in the regional conflicts that have been and will probably continue to be the most likely areas of engagement for U.S. maritime power. The addition to the force of ships that can launch large numbers of long-range missiles against land targets will mean that, in situations where the carriers would initially be at high risk, the other forces can reduce the opposition. The combination of aviation and shorter range guided weapons can then operate more effectively with significant protection from prohibitive losses by the preparatory and supporting attacks of the long-range missile systems. In addition to supporting the carriers the new kinds of forces could project enough military power by themselves to accomplish many missions.

Thus, the new kind of fleet the panel visualizes would afford considerably greater flexibility than exists today in projecting firepower ashore. Not least of the benefits of diversifying the forces in this way would be the distribution of more firepower among given numbers of ships, so that more of them count in the essential strike role that underlies our command of the seas and their periphery. Loss of one of the smaller surface ships in combat would have a relatively lesser impact on total combat power than loss of a carrier, while the latter will be made less likely by the presence of the increasingly capable smaller ships.

The transfer of combat power ashore by the fleet is embodied in the Marine Air-Ground Task Force (MAGTF), as it will evolve. Emphasis on Third World conflicts in the use of these forces does not imply that the sophisticated and advanced technology of future carrier and amphibious forces will not be needed to overcome Third World opposition. Indeed, as recent experience (in the South Atlantic, North Africa, and the Middle East) has demonstrated, rapid defeat of military challenges by Third World arms can yield large benefits on the international scene and is a most desirable capability for the United States to emphasize. This cannot be achieved without very advanced technical and operational capabilities on the part of U.S. Navy and Marine forces.

Much of the "vision" of the evolving fleet and the strategies for its use that have been presented here depend on long-range missiles distributed among various ships of the fleet for power projection and also for sea control. Limits on the flight ranges and total numbers of tactical conventional cruise missiles could emerge from Strategic Arms Reduction Agreements on sea launched cruise missiles, as discussed by General Secretary Gorbachev after the December 1987 summit meeting, if means cannot be agreed to differentiate tactical conventional from strategic nuclear missiles for treaty purposes. Similar limits on tactical ballistic missiles at sea could follow from the INF (Intermediate Nuclear Forces) Treaty.

Should this happen, the consequences for the current "vision" of the future Navy would be as follows. The critical need for and importance of the information-, communication-, and signature-related technologies would not be affected. There would have to be more reliance on air-delivered weapons for attack of difficult targets; attack aircraft with cruise missiles that can fly to ranges such as have characterized previous agreements in this area could still attack targets at very long range. The shorter-range missiles, whether air or surface launched, would still be very useful, so that the recommendation for a family of missiles, modified to accord with the agreements as necessary, would still be in order.

However, range restrictions on sea-launched missiles could affect the justification for strike missions of the extensive redistribution of long-range firepower among carriers and other ships and submarines that the panel has visualized. The more evenly distributed force mix that the panel has described would thus have to be reviewed in light of the characteristics and utility of the missiles that are actually agreed upon.

## POTENTIAL SOVIET RESPONSES

The USSR has been taking a number of initiatives to advance their maritime warfare capability, many of them in response to the capabilities of U.S. naval power. These have included the building of an SSBN force that has enough strike range to be able to patrol in waters very difficult of access to the United States; strict attention to integrated surveillance, targeting, and C<sup>3</sup>I systems including space-based elements; extension of their usual attention to radio-electronic warfare and cover and deception; the growth of Soviet naval aviation and accompanying, gradually improving cruise missile capability as an ASUW attack force; enhancement of their undersea warfare forces and weapon systems; the building of a surface fleet of increasingly respectable combat strength, including carrier elements; and the expansion of an overseas base structure in Marxist countries of the Third World. If confronted by the evolution of U.S. maritime warfare capabilities and strategy as described above, they may be expected to follow similar trends with even greater intensity. Their responses are therefore likely to include some or all of the following steps:

1. They will continue to pursue Western technology by all the means they have already demonstrated, including developing their own capabilities, "capturing" from the United States and the West through industrial and military espionage, and purchase on the open market wherever they can in the Western and the Third Worlds.
2. They may well continue attempts to expand their overseas base structure to force us to dilute the concentration of our resources and forces, and to be

- able to exercise their own "presence" in areas of regional conflict.
3. They can be expected to become more threatening to our space systems, although they may reserve attacks for the contingency of open, major warfare with the United States. Their actions in this area will not be independent of where the two nations come out on their respective strategic defense programs during the next few years, through negotiations and competition.
  4. They will try to learn about, disrupt, or break up our combat information network by countering and penetrating the individual nodes and links, using cover and deception as is their doctrine today, and enhancing their radio-electronic warfare capabilities even further.
  5. They will take steps to enhance the sturdiness and levels of integration of their own combat information network, further tighten their C<sup>3</sup>I systems, and expand their targeting systems.
  6. They can be expected to develop a stealth program for their offensive forces, and a counter-stealth program for defense, in accordance with the missions of their forces.
  7. They will most certainly attempt to expand their ASW capability while continuing to quiet their submarine force.
  8. They may well adopt similar ideas to those laid out above for long-range missiles and dispersed forces for ASUW and attacking the sea lanes (indeed, OSCAR and KIROV would seem to represent a beginning of moves in these directions), but to do so in ways that are in accord with their own views of missions for their maritime warfare forces.
  9. They may increase emphasis on nuclear attacks against surface ships, including the use of nuclear weapons in the opening shots of a conflict, because the enhanced and dispersed firepower of the U.S. surface fleet may make nuclear weapons appear more attractive as a means to deal with a much more complex array of opposing forces. This may represent an area where, in a severe crisis, the Soviets might believe that the

isolation of the forces at sea could make a nuclear "signal" a viable tactical option.

Both the United States and the USSR are moving toward powerful undersea strike forces that will be very hard to detect and defend against. The side that wins the information war for detection, tracking, targeting, and denial of these capabilities to the other side will have the edge.

The United States and the West are ahead of the USSR in the critical areas of technology, and current trends suggest that we might widen the lead. However, the effectiveness of the Soviet system in fielding new technology rapidly is an important element in the competitive strength of their forces. In addition, their more centralized command and management system gives them important operational advantages for carrying out missions important to them. The important capabilities are included in the area they call "radio-electronic warfare," and in C<sup>3</sup>, counter-C<sup>3</sup>, and the combat information network--the area we have defined as radio-electronic battle management in this report. Therefore, if they are able to "capture" our technology and apply it promptly--and the anticipated trends in internationalization of Western technology can help them in this--U.S. technological advances in these most critical areas could actually lead indirectly to a net Soviet military advantage in any future maritime conflict over maintenance of the sea lines of communication that are vitally important to us.

Thus, we cannot afford to have poorly organized C<sup>3</sup>, to have ASW lag far behind submarine quieting, to allow our opponents' ability to hide airborne targets to out pace our ability to find them or to hide our own surface and air systems, or to allow the Soviets to threaten our space systems in ways we cannot respond to, while theirs operate freely or well protected. The Navy and the nation as a whole must shape both our priorities and our ways of managing our programs and operations to deny what could potentially be Soviet net advantages arising from their adaptation of U.S. technological advances in these critical areas to missions important to them. The United States must prosecute its programs to preserve for ourselves the advantages conferred by the technology.

## ACHIEVING THE POTENTIAL CAPABILITIES

The following directions of movement for development of the Navy of the twenty-first century are the most important to emerge from this study. Many others, at a more detailed level, are included in the reports of the technology groups and of the special projects that present the detailed analyses of the many different areas of technology that were examined.

### A. MANAGEMENT

#### 1. Resources and Priorities

Overall, the resource issue vis-a-vis changes in direction in major Navy systems and force structure over the next 30 to 50 years is the most significant and difficult issue the Navy will face in attempting to come to grips with the implications of advancing technology.

Resource allocation implies priorities. Following are the panel's views of the key action priorities implied by the results of this study. The order of listing should not be taken as a firm priority recommendation, but neither should the order be viewed as entirely accidental.

- The surveillance- and information-related systems, and ensuring connectivity among them and with fleet elements and commanders.
- ASW.
- Assuring the availability of militarily essential space functions.

- The signature-related technologies, pro and counter.
- Concepts for acquiring large numbers of cost-effective standoff munitions.
- Beginning the acquisition of new kinds of missile ships and submarines.
- Restructuring the amphibious forces.
- Manpower and its concomitants.

## 2. The Information Area and Radio-Electronic Battle Management

The panel believes that because the information area is so complex and touches on so many different Navy activities it will need top-level attention and support within the Navy. Also, since many of the resources must be shared with all the Services and national agencies, and much of the information is to be used by all, there is a need to define which subsystems are Navy-unique and which are to be shared, and to work out agreements and organizational arrangements to make it happen. It is recommended that the CNO take the initiative in starting such cooperative efforts, on a scale and in directions compatible with the Navy's needs in building the combat information network including surveillance systems and other supporting systems.

## 3. Space

Space control is an issue of paramount importance to maritime warfare and to the Navy. The development of U.S. ASATs has been held back in recent adjustments of the U.S. defense budget. This precludes either the Unified Space Command or the Navy from developing ASATs for destroying such Soviet satellites as EORSAT and RORSAT in case of conflict, and from developing ASATs as a deterrent against the USSR attacking U.S. satellites of critical importance to the Navy and to the nation's maritime warfare posture. In a similar way, the issues of SDI testing and deployment will have serious implications in these areas, from the viewpoints of both space control and defense against ballistic missiles used against the fleet.



In the absence of U.S. steps to build a deterrent to Soviet military actions in space, and to counter such actions if they are taken, the USSR will be in a position to control access to and use of space in the event of a major conflict. The U.S. Navy (and the other Services) could not function effectively without access to space and when subject to unopposed Soviet observation from space. Establishing requirements for space systems important to the Navy and supporting their development, acquisition, operation, and protection regardless of which Service or Agency is responsible is among the highest priority issues for the highest levels of Navy management.

#### **4. System Acquisition**

The Navy must take steps to reduce the development and acquisition cycle time in the combat information network and related areas, because there is a mismatch between the rapid time of technological advance (on the order of 5 years and shrinking) and the growing acquisition cycle time (on the order of 7 years and growing). This means more use of ad hoc, rapidly prototyped developments (i.e., without formal full-scale development and militarization); more use of developments in the field by operating forces, as is happening now in, for example, the POST and the JOTS; and more attention to early replacement and redundant use of less expensive, easily replaceable off-the-shelf commercial components in place of militarization for long utilization.

Accelerated introduction of selected systems with higher risks in both technical and operational learning may be necessary; the use of new technologies while they are still new, in the high-priority areas, is essential if the United States is to maintain its lead in deterrence. In appropriate cases such use can be accelerated by initial application in test beds that later become prototypes and that can be transferred to operational use.

### 5. Nuclear Weapons With the Fleet

The panel believes that the Navy's posture with respect to nuclear forces will need extensive attention by the CNO. This is an area of increasing importance to the United States, involving interactions with the USSR in maritime strategy, survivability, and arms control.

### B. RESEARCH AND DEVELOPMENT

Vigorous R&D efforts will be required in all the important areas that have been described if the Navy and related maritime warfare forces are to capitalize on the benefits that the advancing technology will offer. In some cases the advances will be forced by threat, events, and the march of technology on the international scene and in the commercial world, the R&D will be essential if the United States is to maintain its current supremacy in the maritime warfare area. In other cases, emerging technology will offer unparalleled opportunities to accomplish new tasks and missions, or to improve significantly the effectiveness and efficiency of current tasks and missions. In either case, the Navy's R&D program will hold the key to the transformations in the Navy and in maritime warfare that the Panel has envisioned.

### C. RESOURCES

The new capabilities, types of force, and force elements described in the preceding sections of this report will obviously require extensive resource expenditure. Such expenditures will join those that are pending for force and system acquisitions already under way, many of which will be in the acquisition process for many years. Resources will also be needed to continue operating the forces in being, as well as for the R&D programs discussed in the previous section.

The panel did make some very coarse estimates of the costs that might be involved in developing, procuring, and operating representative numbers of the extended and new capabilities described. Included in these estimates were space systems; the

combat information network as it has been described here; new kinds of ships, submarines, and aircraft; renewal of existing kinds of ships, submarines, and aircraft; and large numbers of long-range missiles (numbering in the hundreds of thousands, in accordance with the rationale given in section 9A). These cost estimates were compared with historic and projected Navy budgets, and with the current values of the Navy's capital equipment embodied in ships, aircraft, and weapons.

The resulting total costs were considered in light of recent Navy acquisition budgets, which have been on the order of \$40 billion to \$60 billion per year in 1988 dollars. Overall, the costs estimated for evolution of the Navy in the directions discussed appeared consistent with costs and budgets that might be involved over a 30- to 50-year period in replacing everything now in the Navy inventory when it comes to the end of its useful life--a renewal that would take place over such a time period in the normal course of events in any case. We note that in the broad time span over which the renewal was considered to take place there will be ample flexibility to adjust to the economic vagaries of the times and still pursue the long-term objective.

The panel did not give detailed attention to the mix of platforms, weapons, and information-related systems in making its coarse estimates of future Navy costs. The allocation of resources among these assets and among various types within each category, over the half-century in view, will doubtless vary from that with which we are familiar today. Of special note was the fact that the missiles, the information and battle management/C<sup>3</sup> (REBM) systems, and the space systems would become major cost drivers in such a force renewal, in greater proportion than we have been accustomed to in the past. This will be true even though the Navy will share the costs of the space, information, and worldwide communication systems rather than paying for the entire systems from its own budgets.

## POSTSCRIPT

None of the technologies that emerged from the panel's explorations and that are described in this report are totally unknown today. While many of them are in the rudimentary stages of application, many are firmly in hand, although in some cases they may not yet have been applied extensively.

The fact that the "vision" of the Navy of the twenty-first century that emerges from this study has not been based wholly on radically new technologies discovered during the study should not be allowed to mask the importance and potentially revolutionary nature of the trends in maritime warfare systems and operations that the study anticipates. The panel has identified trends in threat, technological application, and demands for resources that have long been under way, and that are likely to accelerate during the next few decades. If the Navy were to remain static in its form and function it would become an obsolete force, unable to carry its weight on the world scene or to contribute to the national security in the ways that have become traditional for our maritime warfare forces.

The directions of force evolution and the new kinds of systems the panel foresees portend great change in the way the Navy will be built, organized, and operated. As a result of its deliberations, the panel foresees possibilities such as delivering nonnuclear firepower from submarines that, in some circumstances, can be similar in mass and impact to that deliverable from carriers, at much less risk in warfare with our most capable adversaries; the possibility of engaging important Third World targets that threaten our interests, with much greater economy of force than is now possible and with far less risk of politically embarrassing losses of forces and personnel; and the

ability to sustain presence and to deter or counter hostile action against U.S. and Allied interests with much lower expenditure of resources than is now possible for comparable action.

All such possibilities suggest that by judicious applications of technologies that exist now or that are just appearing on the scene, the Navy can evolve in directions that lead rather than lag the advance of military potential on the world scene. The United States could then continue to protect its interests worldwide from a position of maritime dominance. This would be a major achievement, and the potential for reaching it with rationally predictable technologies should be viewed as a national strength of the first magnitude.

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